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## Dynamic Analysis of Vein Calcite in an Area of Non-coaxial Deformation

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**Abstract** - Stress orientations determined from twinned vein calcite in three generations of shear and extension fractures, now veins, were compared to those predicted on the basis of vein orientation and movement sense. The determined and predicted stress orientations compare closely for extension veins, but not for shear veins. Dilation of extension fractures, filling with calcite, and twinning of the calcite all occur under the same uniform stress that produced the extension fractures. Twinning of calcite in shear fractures is caused by stresses unrelated to those present during shear fracturing. Subsequent stresses have only minor effects on calcite in extension veins, but may greatly alter calcite fabrics in shear veins.

### Introduction

An understanding of the relationship between stress and the resulting structural features is one of the basic goals of structural geology. To this end, several techniques for the determination of stress orientations and magnitudes have been developed, largely through the experimental deformation of rocks and minerals. Of these, the most widely used is the analysis of twin lamellae in calcite. Calcite has been used successfully to determine stress orientations in a variety of geologic settings ranging from slightly deformed sedimentary rocks to highly strained metamorphic rocks (for review, see Friedman and Sowers, 1969; Carter and Raleigh, 1969).

Studies utilizing primary and recrystallized calcite in sedimentary rocks or recrystallized calcite in metamorphic rocks are limited to areas of relatively simple deformational history. In areas of non-coaxial deformation, the calcite will have been subjected to several different stress systems. Resolution of these superimposed stresses from a single generation of calcite generally is not possible.

Calcite in syn-tectonic veins has been largely overlooked for dynamic analysis. Veins offer great promise for dynamic analysis because they are nearly ubiquitous in deformed rocks. Most originate as syn-tectonic fractures that are subsequently dilated and filled with minerals such as calcite. In an area of non-coaxial deformation, it is common for several generations of veins to develop, each reflecting a different stage in the stress history. Twinning of calcite in each vein should record the incremental stress orientations present during the formation of that vein. By analyzing a number of veins formed during different increments of deformation, reconstruction of the superimposed stress systems should be possible. This study investigates this possibility by comparing stress orientations derived from twinned vein calcite to those predicted independently on the basis of vein orientation and movement sense in rocks that have undergone non-coaxial deformation.

### Sample Descriptions

Samples for this study are from the Ordovician Lincolnshire Formation exposed in the Shenandoah Valley near Strasburg, Virginia (Fig.1). Structurally, the area is on the western limb of the Massanutten synclorium, a doubly-plunging asymmetric fold. Bedding in this location is relatively planar and dips uniformly to the southeast at approximately 40 degrees. Here, the Lincolnshire Formation is a fine-grained biomicrite with abundant chert nodules.

Several generations of calcite-filled shear and extension veins are present. Two sets of extension veins, both occurring in an en echelon fashion were found. Most individual extension veins are planar, but some are slightly sigmoidal. Shear veins can be differentiated from extension veins by their offset of fossils, chert nodules, and other veins. Veins vary in thickness from 0.3 to 1.5 cm with extension veins as a group being somewhat thicker. Sparry calcite fills both vein types and increases in grain size toward the center of the vein. Fibrous calcite, typical of many syn-tectonic veins (Ramsay, 1980) was not observed in these samples. Some of the calcite in the oldest shear veins is brecciated and cemented with a second generation of calcite. No evidence of a replacement origin was observed and we believe that all veins originated by the filling of dilated fractures.

Based on cross-cutting relations, three generations of veins were identified. These are shown schematically in Figure 2. The first, or oldest, generation consists of extension veins only. Both shear and extension veins formed during the second generation. Contemporaneity of the shear and extension veins in this generation is established by mutual offset and examples where one type passes uninterrupted into the other (see Fig. 2). The third, or youngest, generation consists of shear veins only.

Outcrop relief was sufficient to allow accurate measurement of vein orientations. Relative movement directions were determined from slickenside orientations on the vein walls and from offset of older veins or other features. Mutually perpendicular thin sections were prepared from oriented samples collected from each vein type in each of the three generations. The orientation of calcite c-axes and twin lamellae were measured with a universal stage, plotted on an equal area stereonet, and rotated back to true geographic coordinates.

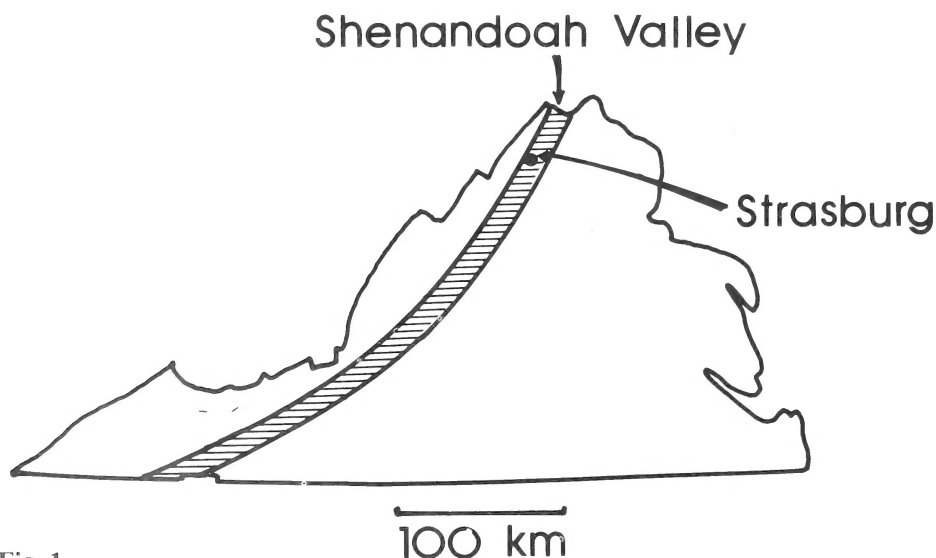


Fig. 1.

Index map of Virginia showing Shenandoah Valley (ruled pattern) and study area near Strasburg.

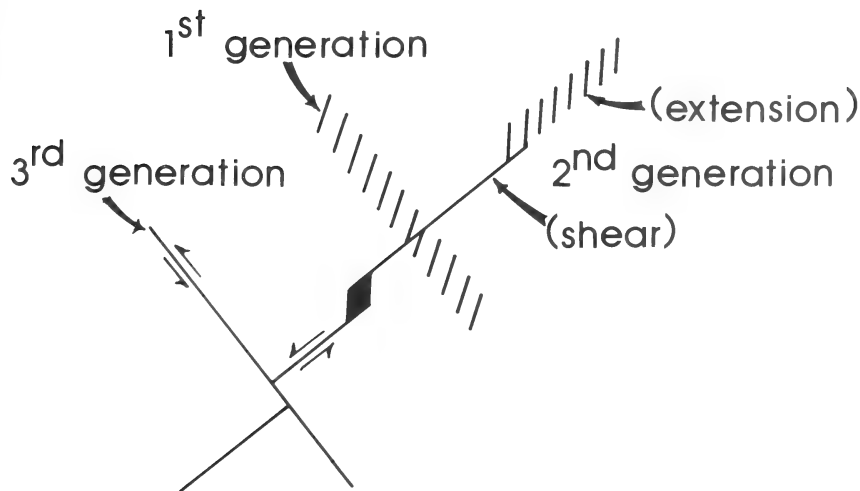


Fig. 2.

Schematic diagram showing relative ages and orientations of veins. Diagram would correspond approximately to a vertical east-west cross section with west to the left.

### Stress Analysis

Stress orientations were determined for each set of veins from the dynamic analysis of the twinned vein calcite. In order to test the hypothesis that these orientations represent incremental stress orientations related to the formation of the vein, an independent and accepted technique for the determination of the stresses is required. For this purpose, stresses were predicted on the basis of the vein orientation and movement sense. With these data and assuming that all veins originated as fractures, stress orientations can be predicted from brittle yield theory.

### Predicted Stress Orientations

According to brittle yield theory, shear and extension fractures form at certain angles to the principal stress axes (Price, 1966; Anderson, 1951). In a general compressive stress field ( $\sigma_1 > \sigma_2 > \sigma_3$ ), such as would be expected in an area undergoing folding, extension fractures form normal to the least principal stress,  $\sigma_3$ . Shear fractures form in a conjugate set that intersects along the intermediate stress axis,  $\sigma_2$ . The maximum principal stress,  $\sigma_1$ , bisects the acute angle between the shear fractures which is typically about  $60^\circ$ . Where only one of the conjugate shear fractures is observed, as is the case for the third generation of shear fractures,  $\sigma_1$  will lie at an angle of  $30^\circ$  to the fracture in a plane defined by the pole to the fracture and the slip direction (slickensides) in a direction consistent with the relative movement sense of the fracture.  $\sigma_3$  will be normal to  $\sigma_1$  in this same plane and  $\sigma_2$  will be normal to both  $\sigma_1$  and  $\sigma_3$ .

Using these relationships, principal stress orientations were predicted for each generation of veins (Fig. 3). For the first generation, consisting of extension veins only, a unique determination of  $\sigma_1$  and  $\sigma_2$  is not possible. Both will lie in the great circle shown in Figure 3a. The relative orientations of shear and extension veins in the second generation is consistent with brittle yield theory, further supporting their synchronous development.



### Dynamic Analysis of Vein Calcite

Stress orientations were determined from twinned calcite in each vein according to the method of Turner (1953). Twinning on the  $e$  plane (0112) in calcite is known to be a mechanically-induced phenomenon. For any grain, the compression axis ( $\sigma_1$ ) most favorable for twinning is oriented at an angle of  $45^\circ$  to the twin plane and  $71^\circ$  to the  $c$ -axis, in the plane containing the pole to the twin plane and the  $c$ -axis. The tension axis ( $\sigma_3$ ) is normal to the compression axis in the same plane. Compression and tension axes are determined for a number of grains yielding a statistical orientation of  $\sigma_1$  and  $\sigma_3$ , respectively. The point of the highest concentration on a contoured diagram is taken as the orientation of the axis for that diagram. It should be noted that this method actually determines the axes of strain (shortening and extension) and that the axes of stress are derived by assuming a coaxial relationship between stress and strain. Rocks deformed in the laboratory typically exhibit a coaxial stress-strain relationship (Friedman, 1963).

For Turner's method to be valid, the calcite grains must be randomly oriented in order that all twin lattice directions have equal chance to twin. The lack of any preferred orientation in the  $c$ -axis fabrics of the veins studied indicates that this condition is met.

Figure 4 shows the compression and tension axis diagrams for each vein. Several observations can be made from these plots. (1) The compression and tension axis fabrics of older veins are less well defined than those of younger veins. (2) For each vein generation, tension axis fabrics are generally better defined than compression axis fabrics. (3) For the second generation, the compression and tension axis fabrics of shear veins are less well defined than those of extension veins. (4) For the second generation, compression and tension axes determined from the extension vein do not agree with those from the shear vein.

By comparing the determined to the predicted stress orientations (Fig. 5), it is apparent that stresses determined from twinned calcite in extension veins agree well with those predicted from vein orientation (Fig. 5a & b). In contrast, stress orientations determined from calcite in shear veins show no correlation to those predicted from vein orientation or to those determined from extension veins of the same age (Fig. 5c & d).

### Discussion

The close correlation between stress orientations determined from calcite in extension veins and the lack of correlation in shear veins can be explained by differences in the evolution of the two vein types. Extension veins formed from extension fractures that were immediately dilated and filled with calcite. The calcite was twinned before the stresses responsible for the fracture had changed orientation. Hence, the stresses recorded by the twinning of the calcite are the same as those responsible for the fracture.

Subsequent stress systems had relatively minor effects on the calcite in extension veins, dispersing the compression and tension axis fabrics somewhat. Rotation of existing twin lamellae and formation of a limited number of new twins are responsible for the broader compression and tension axis maxima in the older extension veins. The original fabric, however, remains largely intact. Apparently, once the calcite is twinned during the initial increment of stress, twinning by additional stress increments becomes less likely.

In shear veins, the lack of agreement between stress orientations determined from calcite twins and those predicted from vein orientation is due to a more complex dilation and filling history. At the time of shear fracturing, the normal stress acting across the fracture was sufficient to prevent dilation and filling. Only when the stresses had changed orientation with respect to the fracture, could the fracture dilate and fill with calcite. Twinning of the calcite occurred at a later time by stresses unrelated to those responsible for the initial

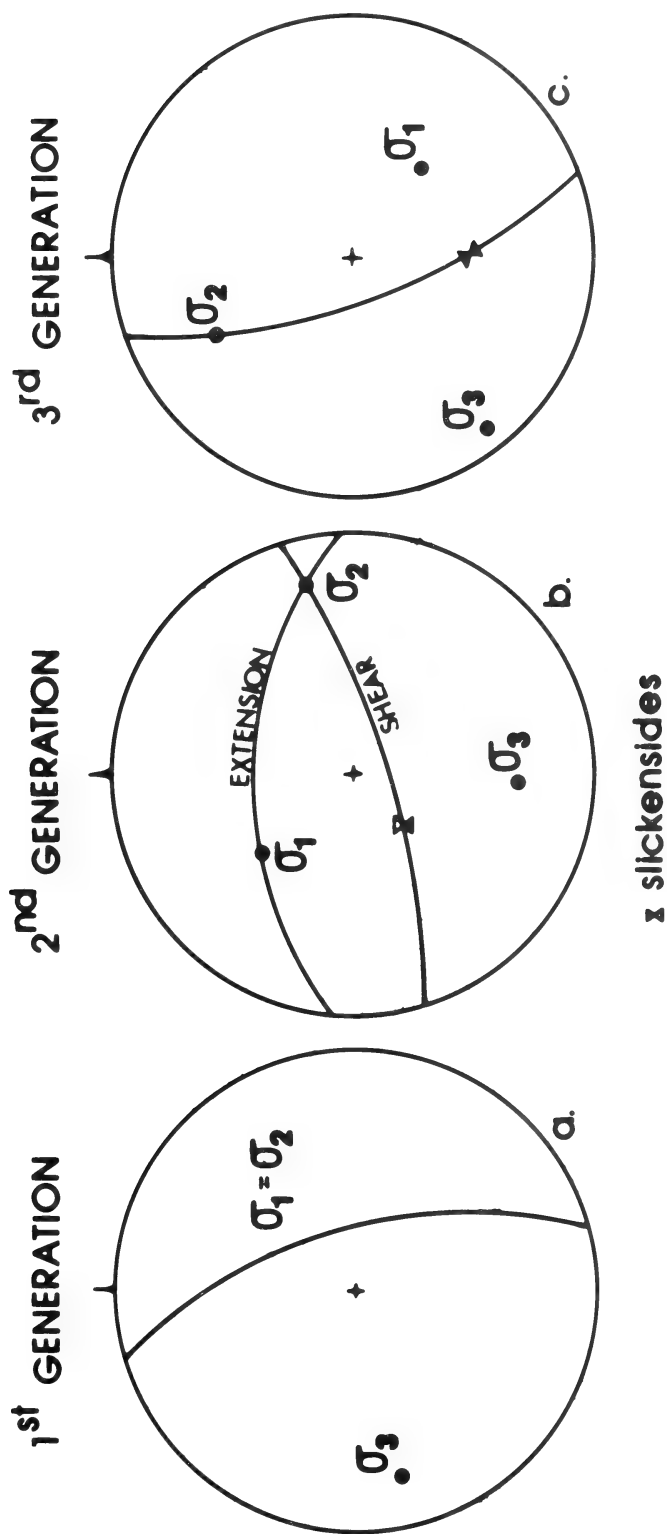


Fig. 3

Predicted stress orientations for the three generations of veins. Vein orientations plotted as great circles. Slickensides on shear veins indicate relative movement directions. In the first generation (a),  $\sigma_1$  and  $\sigma_2$  both lie in the plane of the vein.

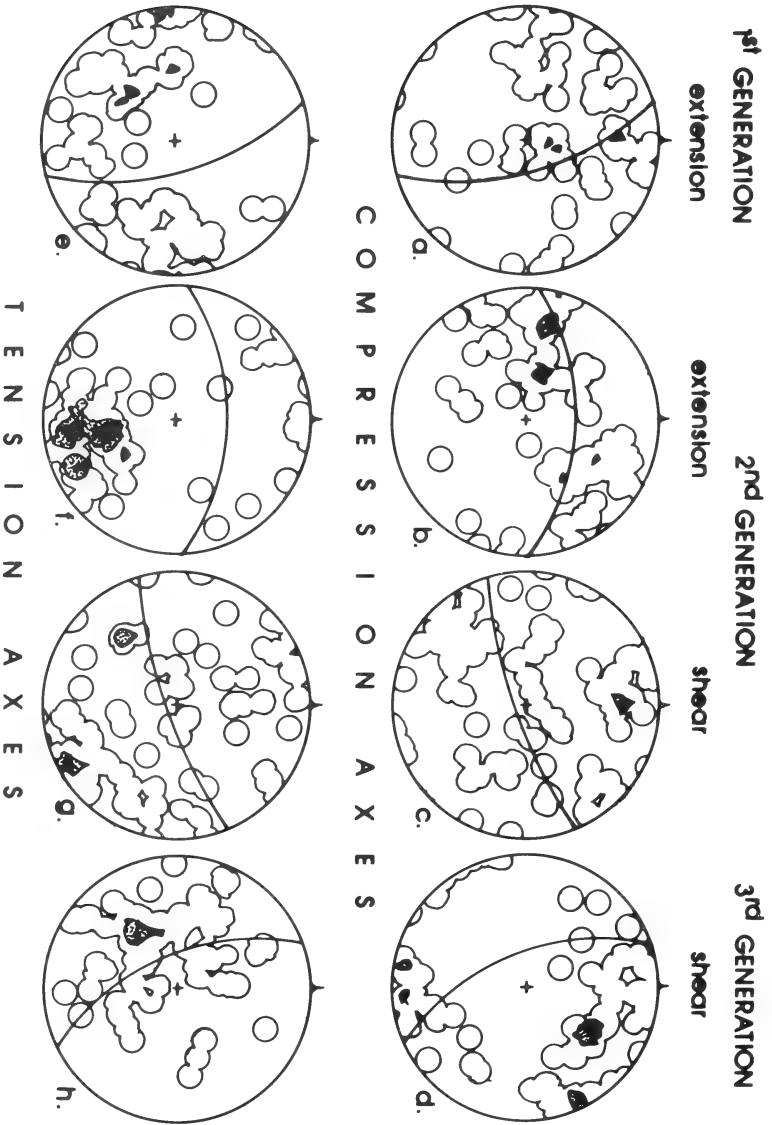


Fig. 4.

Contoured compression and tension axis diagrams for the three generations of veins. Contours at 1.5, 6, and 9% per 1% area. Veins plotted as great circles. The number of lamellae sets measured are 68, 62, 72, and 61 for diagrams a, b, c, and d, respectively.

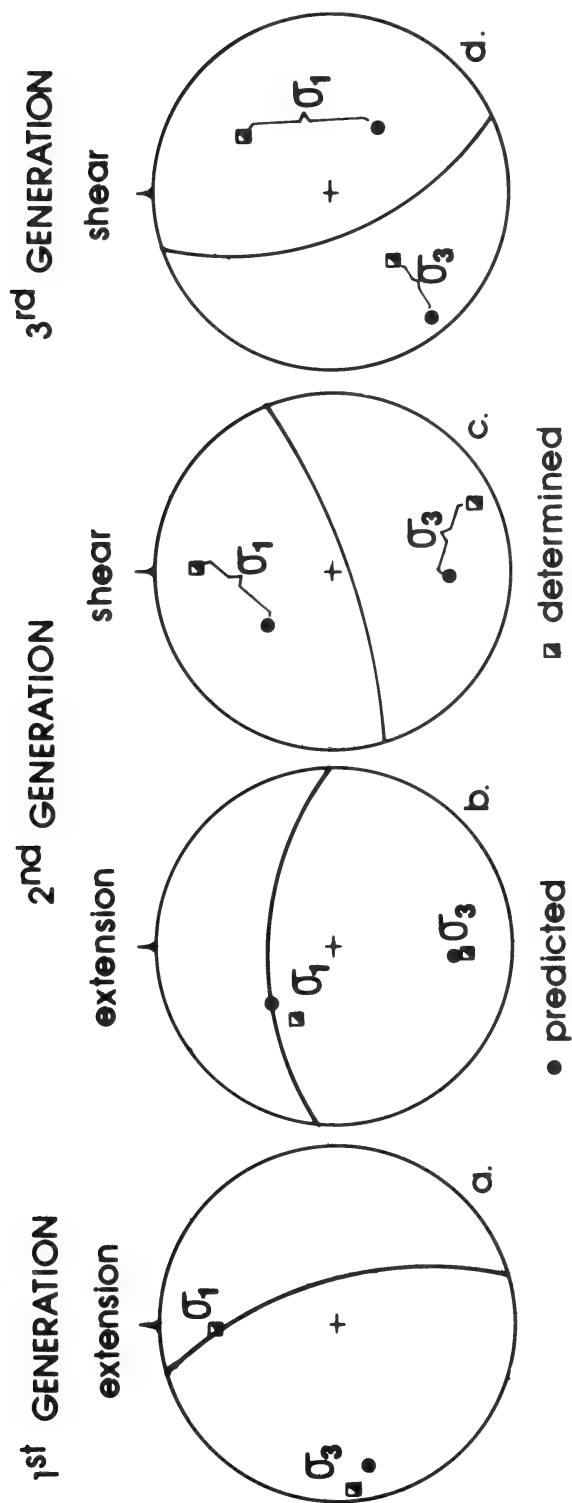


Fig. 5

Comparison of stress orientations determined from calcite twin lamellae to those predicted from vein orientation and movement sense for the three generations of veins. Note agreement between determined and predicted stresses in extension veins (a and b) and lack of agreement in shear veins (c and d).

shear fracture. Therefore, the stress orientations derived from calcite in shear veins bear no relationship to those predicted from vein orientation or to those determined from extension veins of the same fracture generation. The calcite in shear veins records a later dilation and filling event. It is possible that the orientation of the shear veins is not in accord with brittle yield theory. Preexisting anisotropies could have caused the shear fractures to form in orientations different from those predicted by brittle yield theory. However, the homogeneous nature of the beds sampled would argue against this.

It also appears that shear veins were affected more than extension veins by subsequent stress systems. Dispersal of compression and tension axes occurred not only by rotation of twin lamellae and new twinning, but also by renewed shearing and brecciation of the original vein filling. Twinning of the calcite that cements the vein breccia fragments occurred at an even later time; hence, it is unrelated not only to stresses responsible for the shear fractures, but also to those associated with twinning of the initial generation of vein calcite. Shearing and brecciation were not observed in extension veins. This could be a result of their shape and extent. Long, continuous shear veins may have been more susceptible to subsequent shearing than the short, discontinuous, en echelon extension veins.

In summary, this study indicates that dynamic analysis of twinned calcite in extension veins may be used to determine the incremental stress orientations present at the time of vein formation. Dilation of the extension fractures, filling with calcite, and twinning of this calcite occur in a geologically short period of time, before the stresses responsible for the fractures change orientation. Because dilation and filling of shear fractures are not immediate, twinned calcite in shear veins does not record stress orientations present during formation of the shear fractures. Dilation, filling, and twinning of the calcite in shear veins occur after the stresses responsible for the fractures have changed orientation.

Subsequent stress systems may alter, but do not destroy, the original compression and tension axis fabrics of extension veins. Each vein records the stress orientations present during its formation. In an area where several generations of extension veins are present, a detailed record of the stress history is preserved. Interpretation of this history requires only that the relative age of each vein be known.

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**Microorganisms Isolated From Rhinocyllus conicus<sup>1</sup>, A  
Weevil Introduced into Virginia for Thistle Control.**

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ABSTRACT

Flower heads of musk thistle, Carduus thoermeri Weinmann, infested with Rhinocyllus conicus Froelich were collected to study the prevalence of potentially pathogenic microorganisms in R. conicus in Virginia. In 1978 and 1979, weevil-infested flower heads from three field sites located in Pulaski, Frederick and Warren Counties were caged in the laboratory until adult weevils emerged. Dead larvae and adults of R. conicus remaining in the thistle heads were screened for microorganisms associated with each insect stage. Several species of bacteria were isolated from the larvae, the most common being Bacillus cereus Fr. & Fr. and B. megatherium DeBary. A fungus Beauveria bassiana (Bals.) was one of the few pathogens isolated from adult weevils. Rate of infection was low in both years. Hemolymph and gut tissues of healthy weevils, as well as host plant tissue did not harbor any pathogenic organisms.

INTRODUCTION

Rhinocyllus conicus Froelich was imported from Europe into the U.S.A. and released in 1969 for the control of musk thistle (Carduus thoermeri Weinmann) and plumeless thistle (Carduus acanthoides L.). The weevil is presently well-established in Virginia, and in several other states (Surles et al. 1974, Rees 1977, Goeden and Ricker 1977, Puttler et al. 1978). Impact of predation and parasitism on R. conicus has been reported (Dowd and Kok 1981, 1982), but no documentation of the incidence of pathogenic microorganisms in the various populations of the weevil in the U.S.A. is available. Because we have occasionally encountered evidence of diseased weevils during field surveys, the prevalence of potential pathogens in R. conicus was investigated in 1978 and 1979 as part of our study of mortality factors affecting this introduced weevil.

METHODS AND MATERIALS

One hundred musk thistle flower heads containing large numbers of developing larvae of R. conicus were collected from each of 3 field sites

<sup>1</sup>Coleoptera: Curculionidae

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Table 1. Pathogenic microorganisms isolated from dead larvae and adult Rhinocyllus conicus in Virginia.

Microorganism	Type <sup>1</sup>	Host life stage	No. of sites detected	% <u>R. conicus</u> infested <sup>2</sup>	
				1978	1979
<u>Bacillus megatherium</u>	B	larva	2	12.5	0
<u>Bacillus cereus</u>	B	larva	2	20.3	0
		adult	1	3.1	0
<u>Serratia</u> sp.	B	larva	1	6.3	0
<u>Streptococcus</u> sp.	B	larva	1	3.1	0
<u>Micrococcus</u> sp.	B	larva	1	3.1	0
		adult	2	6.3	0
<u>Beauveria bassiana</u>	F	adult	2	0	5.9
<u>Fusarium</u>	F	larva	2	4.7	0

<sup>1</sup> B = Bacteria, F = Fungus

<sup>2</sup> Based on specimens that were dead and dissected from thistle heads: 96 larvae and 96 adults in 1978, and 60 larvae and 60 adults in 1979

located in Pulaski, Frederick and Warren counties, VA during mid-June, 1978. The thistle heads were individually held in 0.9% clear plastic containers in the laboratory and dissected in August after weevil adults emerged. Dead specimens totaling 192 (32 larvae and 32 adults/site) that remained within the heads were randomly selected for screening of associated microorganisms. Whole specimens were surface sterilized by the technique of Poinar and Thomas (1978), ground in distilled water, and inoculated onto plates of nutrient agar. The resulting bacterial colonies were identified by colony morphology, Gram stains, endospore stains, catalase, Voges-Proskauer, and cytochrome oxidase tests. Fungal colonies were slide mounted in Guegen's solution and examined. Representative colonies of microorganisms were sent to the diagnostic laboratories at the University of California, Berkeley, and to the U.S.D.A. Agriculture Research Center, Beltsville, MD, for confirmation. In 1979, another 60 specimens of dead larvae obtained from musk thistle flower heads from the same field sites were screened for associated microorganisms. Over 500 adults field collected in June, 1978, and held in equal numbers (100/treatment) at 5 different temperatures (15°, 20°, 25°, 30°, 35°C) in the laboratory, and 500 adults overwintered in field cages were examined for signs of fungi at time of death. Samples of 60 specimens were sent for screening of pathogenic microorganisms. In addition, hemolymph and gut tissue were removed from over 50 healthy adult weevils dissected from thistle heads, plated, and examined. Resulting colonies from a random sample of 12 weevils were sent to diagnostic laboratories for identification. Sections of bud tissue from 12 thistles randomly selected from over 50 buds examined, were treated in the same manner to determine the presence of pathogenic microorganisms in host plant tissue. Only 12 samples of healthy weevils and bud tissue were sent for identification because our initial examinations showed a lack of potential pathogens in them.

#### RESULTS AND DISCUSSION

No pathogenic microorganisms were isolated from the gut or hemolymph of healthy weevils collected from thistle flower heads or from the thistle bud tissue. Five bacteria and 2 fungi were found in dead larvae and adults. Of the potential pathogens isolated from the larvae in 1978 (Table 1), two bacteria, Bacillus cereus Fr. & Fr. and B. megatherium DeBary, were encountered most frequently. Both species, however, are also known to occur widely in soil and other material (Buchanan and Gibbons 1974) and their invasion may have been secondary. Two bacteria isolated from the adult weevils dissected from thistle flower heads in 1978 were Micrococcus sp. and Bacillus cereus. A fungus, Beauveria bassiana (Bals.), was isolated from 5.9% of the adults held in the laboratory from 1978 into 1979 and



from adults overwintered in field cages. No pathogenic organisms were isolated from larvae in 1979. The absence of pathogens in thistle bud tissue, and the hemolymph and gut tissues of healthy weevils, suggests that the isolated microorganisms are invaders and are not a normal component of healthy weevils or thistle tissue.

Some of the isolated pathogens (*Serratia* sp., *Streptococcus* sp., *Beauveria bassiana* and *Bacillus cereus*) have been previously reported infecting other Curculionidae (Weiser 1969, Buchanan and Gibbons 1974, Cantwell 1974, Thomas and Poinar 1973, and Poinar and Thomas 1978). Due to the widespread occurrence of several of the pathogens and their known ability to invade as secondary agents, their importance in relation to *R. conicus* appears to be more as secondary rather than primary invaders. Although adults do not seem to be frequently attacked, about one-third of the samples of dead larvae in 1978 contained microorganisms which were potentially pathogenic. This suggests that disease microorganisms may play an important role in contributing to mortality in the larval stage, even though the pathogens are not always the primary cause of death. The absence of pathogens in larvae in 1979, however, indicates that incidence of disease in *R. conicus* varies greatly between years, and is probably influenced by the prevailing predisposing conditions for infection. The low infection rate and absence of disease epidemics in the various field populations of *R. conicus* which have been established for over ten years confirm that pathogenic microorganisms are not major mortality factors of the weevil.

#### ACKNOWLEDGEMENTS

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## An Evaluation of Small Rodents in Four Dismal Swamp Plant Communities

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### ABSTRACT

Diversity and density of small rodents in the Dismal Swamp are believed to be low. Reasons for this may be excessive predation, heavy interspecific pressure from large rodents, lack of suitable habitat, low food availability or flooding.

Rodent populations were evaluated using live-traps and pitfall traps in four different Dismal Swamp plant communities. Habitat was compared on the basis of phytomass studies previously reported. Flood levels were recorded during live-trapping sessions. Mast from trees was collected in modified mast collectors, and fed to Peromyscus leucopus in the laboratory.

Only two small rodent species were captured: Ochrotomys nuttalli and Peromyscus leucopus. The low density of these animals is believed to be limited by lack of food combined with unsuitable habitat. Flooding appears to have a great effect on small rodent diversity by preventing the establishment of species that are not at least mediocre swimmers and somewhat arboreal.

### INTRODUCTION

Rodent population studies conducted in the Dismal Swamp have historically yielded low densities and diversity (Handley 1979). There are at least five factors which may limit the rarity and density of small rodents in a swamp habitat. These are excessive predation, pressure from interspecific competition, sparse undergrowth (or cover), extensive flooding, and insufficient food.

Population studies of Dismal Swamp predators are practically non-existent, but it is generally believed that the predator numbers are low. This also appears to be the case with larger rodents, such as rats and squirrels, so these animals are unlikely to impose a severe interspecific competitive pressure on the small rodents.

The importance of dense undergrowth to small rodents has been demonstrated by several workers (e.g., Miller and Getz 1977, Goodpaster and Hoffmeister 1954, M'Closkey and Lajoie 1975). However, a paucity of comparisons exists between rodent species diversity in mesic versus hydric habitats. A few rodents can survive well in hydric habitats, but the number of different species which can survive is obviously restricted by the necessity of being scansorial and natatorial. The role of food in

controlling the abundance of many vertebrates has been well documented in the literature; Lack (1954), working with birds, was the first researcher to emphasize this regulatory role of food.

The objectives of our study were to (1) qualitatively and quantitatively evaluate the small rodent populations of four vegetatively different Dismal Swamp stands, and (2) investigate three factors which have the potential to influence these populations, that is: flooding, undergrowth density, and food availability.

#### Description of the Study Area

The Great Dismal Swamp National Wildlife Refuge was created in 1974 when the Union Camp Corporation deeded a large tract of land to the Nature Conservancy, who in turn donated it to the U.S. Department of Interior (Berkely and Berkely 1976). Parcels of land continue to be added to the Refuge; at present, the Refuge comprises some 40,000 ha. However, the Dismal Swamp proper extends beyond the current Refuge boundaries and has been estimated by Oaks and Whitehead (1979) to be about 85,000 ha. Most of this area is predominantly a peat swamp; peat formation is believed to have commenced about 11,000 BP (Whitehead and Oaks 1979).

The biota of the Dismal Swamp has been considerably disturbed by man, starting in the mid-18th Century, when canals were dug to promote drainage and to transport lumber. Swamp lowlands were later drained for agricultural purposes, considerably reducing the area of the Swamp (Stewart 1979) and altering the water table. The reduction of virgin swamp forest is directly attributable to these human disturbances. Most plant communities consist of second or third growth forest, and include several different seral stages (Levy and Walker 1979). The area is consequently losing many of its swamp characteristics.

Four plant stands, chosen as representative examples of the heterogeneity of the Swamp, have had their vegetation structure quantified by Dabel and Day (1977). These stands were the study areas for this research on small rodents, and the undergrowth density data of Dabel and Day's study were used in determining the effect of habitat upon small rodent populations. The composition of the four forest stands is summarized in Table 1 (from Dabel and Day 1977).

The mixed hardwood stand was in a mesic area with mineral soils (Histic Humaquepts). Its shrub layer was moderately dense, as was its herbaceous layer (due more to the presence of tall canebrakes than to a dense low ground cover). The maple-gum stand had a shrub layer which was less dense than that of the mixed hardwood stand, and an extremely sparse herbaceous layer. This stand previously contained cypress (Taxodium distichum) trees, but these have been unable to reproduce because of competition from maple trees. Similarly, poor germinating conditions prevail in the cypress stand. The lack of cypress seedlings here may prevent replacement of this species; the hardwoods, whose seeds are germinating successfully, are increasing in importance. The cedar stand had a dense shrub stratum made possible by canopy openings caused by the death of the Atlantic white cedar trees, and red maple and blackgum were replacing the cedar trees. Cedar's failure to reproduce may be due in part to the exclusion of fire by man.

The mixed hardwood stand is inundated sporadically and unevenly during the late winter and early spring. During this same period the other stands are usually flooded too. Cypress is the most frequently flooded, maple-gum is next, and cedar, though least flooded, occasionally is covered to 30 cm depths.

Table 1. Dominant tree species in four Dismal Swamp plant communities (Dabel and Day 1977). Data represent relative total biomass, expressed as a percentage.

Tree Species	Mixed Hardwood	Maple- gum	Cedar	Cypress
<i>Quercus laurifolia</i>	32.8			
<i>Quercus alba</i>	17.1			
<i>Liquidambar styraciflua</i>	13.1			
<i>Nyssa sylvatica</i>	11.8	16.6	30.9	14.5
<i>Acer rubrum</i>	9.5	32.9	19.5	18.0
<i>Nyssa aquatica</i>		46.7		
<i>Taxodium distichum</i>				50.1
<i>Chamaecyparis thyoides</i>			46.8	

## MATERIALS AND METHODS

### Field Procedures

In order to evaluate the food supply, mast collections were begun during the spring of 1979, using 15 litter collectors that had been modified to make them bird- and mammal-proof. These collectors consisted of wire mesh baskets 10 cm deep, with a basal area of 0.25 m<sup>2</sup>, placed on wooden legs 50 cm tall. The modifications included the addition of wire mesh strips (7.6 cm wide) around the lower periphery of the basket, preventing rodents from climbing into the basket, and a square of chicken wire (with openings of 2.5 cm) placed on top of the mesh basket, to prevent deer and birds from eating the mast. The collectors, previously used for other studies, had been placed along two parallel lines, at random distances from each other. Bimonthly mast collections were made from September 1979 to July 1980 on all four stands.

Population studies of the small rodents were conducted in May and October 1979 and September 1980. The 1979 studies used live traps, the latter used pitfall traps. Two lines, 125 m long and 40 m apart, were measured in each stand, and 100 Sherman live traps (10 x 10 x 25 cm) were placed along these lines at 5 m intervals, with two traps at each station. The mixture of peanut butter and oats used as bait in May decomposed rapidly, so sunflower seeds were used in October. The traps were checked daily, and captured mice were marked with an indelible pen, for estimating population density. Water depth was measured at each stand during both live-trapping sessions in 1979.

For the pitfall trapping, grids were set up, using four lines 20 m apart, with seven traps 10 m apart on each line. Holes were dug at these grid points and cylindrical 10 tin cans were inserted into the holes. Water was placed in these cans to a depth of 10 cm. Traps were checked every fourth day for 10 days.

### Laboratory Procedures

Mast collected at the four stands was oven-dried at 70° C for 48 hours, and then separated by species and weighed.

In order to determine which species of mast are edible by

small rodents, "cafeteria" tests were performed in the spring and summer of 1980, using wild-caught Peromyscus leucopus, white-footed mice, which had been acclimated to the laboratory, then weighed prior to each use. One specimen, used as a control, was maintained on sunflower seeds. Mast species collected in the Dismal Swamp were fed to two mice. After two days on a diet consisting exclusively of a tree seed, the mice were re-weighed and, if no interpretable results were obtained, the experiment was continued for another two days, or was repeated later. The mast being tested was also weighed at the beginning and end of the experiment; thus, the food consumed could be quantified, as well as the weight losses or gains of the animals. If part of an edible fruit was rejected by the mice, or caused weight loss, it was considered indigestible. In order to determine relative digestibility of each edible fruit, the digestible portion of several samples of each species was recovered and weighed.

In order to determine whether collection time and site differences had a significant effect on mast production, one-way analysis of variance (ANOVA) tests were run on the biomass of the total mast collected. A priori tests were also run, testing for significant differences between groups. The mast biomass data from the mixed hardwood stand were compared with the other stands, as the mixed hardwood stand is a mesic area and the other stands are periodically inundated. In addition, the mast data from the cedar stand were compared with the remaining plant communities, because the cedar stand is the one stand with a true peat soil. In order to look at summer and winter production, July and September biomass estimates were averaged to obtain a summer value for comparison to the mean of January and March; in addition, January's production was compared to July's. Autumn and spring production were compared using November and May values.

## RESULTS

### Small Rodents

Only in the cedar community were both species of rodents, white-footed mice and golden mice (Ochrotomys nuttalli), trapped (Table 2). All four communities had low numbers of rodents. Once marked, none was recaptured, so no population estimates could be calculated. The highest yield of white-footed mouse specimens was in the maple-gum community.

### Production of mast

The mixed hardwood community produced the greatest variety, but the smallest quantity of mast (Table 3). Six species produced between 10 and 25 percent of the annual total. More acorns were found here than at the other communities but they were concentrated in a few baskets.

The maple-gum stand produced the largest amount of mast for the year. The primary contributor, with 81.5 percent, was tupelo gum. Few acorns were found. The distribution of mast species was rather uneven, as indicated by the standard errors. Maple had the most even distribution, whereas oak mast was only found at one basket.

Five different species produced mast in the cypress stand, with tupelo gum (68.3%) the most important. Blackgum, maple, and sweetgum fruits were found in small quantities. Cypress cones were unique to this stand, but were only found in a few collectors. The cypress stand's mast was the least evenly distributed of all the communities.

The cedar stand produced the second most abundant mast, but

this represented only three species. The majority was produced by Atlantic white cedar, but fruits were found in greater quantity at the cedar site than at other sites. Distribution of cedar cones and maple samaras was noticeably even, more so than mast at the other communities.

Table 4 shows the amount of mast, by species, collected at bimonthly intervals during the year. The small amount of mast produced in late spring and summer is notable (Table 4); red maple contributed most then. Red maples produced fruits only from March through May. Tupelo, however, was found mainly in the winter months. Acorns were found at the mixed hardwood stand in every collection period, with most in January, and least in July. However, acorns were never found in abundance.

Table 2. Flood data and results of live trapping in May and October 1979. Each plot was trapped for 400 trap nights during each season.

		Mixed hardwood	Maple- gum	Cypress	Cedar
Flood levels May (cm)		0 - 2	10 - 40	10 - 20	10 - 40
October		0	0	0	0
Number of Animals Trapped					
Species					
<u>Peromyscus</u>	May	0	7	1	3
<u>leucopus</u>	October	1	1	0	2
<u>Ochrotomys</u>	May	0	0	0	3
<u>nuttalli</u>	October	0	0	0	1

ANOVA tests revealed an overall significant ( $p = 0.05$ ) difference in total mast production by community and by collection date. The a priori t-tests indicated (1) no significant difference between the spring and autumn collections, and (2) a significant difference between mast production in July and September compared to January and March, and between that of January compared to July. A significant difference was found between mast production at the mixed hardwood stand and the other stands, but no significant difference was found between the cedar stand and the other combined study sites. Apparently flooding may be important in increasing site differences in mast production, but soil type is not.

Table 3. Mean annual total dry weight of mast collected in 15 collectors, in  $\text{g/m}^2$ , in four Dismal Swamp communities, from September 1979 through July 1980. Values in parentheses are one S.E. Dashes indicate that the species is not found at the community.

Species	Mixed Hardwood	%	Maple- gum	%	Cypress	%	Cedar	%
Tupelo	1.60 (1.60)	17.5 -	28.68 (10.04)	81.5	7.36 (4.04)	68.3	-	-
Cedar	-	-	-	-	-	-	13.76 (1.17)	73.9
Blackgum	1.56 (0.60)	17.1	2.64 (0.92)	7.4	0.64 (0.20)	5.8	1.40 (0.84)	7.5
Maple	1.16 (0.32)	12.7	1.72 (0.40)	4.8	0.64 (0.32)	5.8	3.48 (0.44)	18.6
Sweetgum	0.92 (0.74)	10.1	2.12 (1.24)	5.8	0.39 (0.39)	3.9	-	-
Tulip Poplar	2.32	25.4	-	-	-	-	-	-
Cypress	0.04 (0.04)	0.4	-	-	1.75 (0.60)	16.2	-	-
Oak	1.32 (0.56)	14.5	0.17 (0.17)	0.5	0	0	-	-
Beech	0.20 (0.19)	2.3	-	-	-	-	-	-
TOTAL	9.12 (2.44)	100.0	35.16 (9.64)	100.0	10.77 (3.96)	100.0	18.64 (1.56)	100.0



Table 4. Mean dry weight of mast collected in 15 mast collectors from September 1979 through July 1980, in g/m<sup>2</sup>, at four Dismal Swamp communities, by collection date. Values in parentheses are one S.E. Sites are mixed hardwood (MH), maple-gum (MG), cypress (CY) and cedar (CE). Dashes indicate that the species is not found at the community.

SPECIES	September				November				January			
	MH	MG	CY	CE	MH	MG	CY	CE	MH	MG	CY	CE
Tupelo	1.60 (1.60)	8.49 (7.56)	2.98 (2.04)	-	0	4.69 (2.12)	1.12 (0.76)	-	0	14.90 (5.50)	3.26 (1.92)	-
Cedar	-	-	-	4.47 (0.87)	-	-	-	2.89 (0.51)	-	-	-	4.12 (0.66)
Blackgum	0.69 (0.35)	0	0	0.80 (0.80)	0.70 (0.43)	0.96 (0.51)	0.09 (0.09)	0	0.15 (0.13)	1.57 (0.62)	0.53 (0.15)	0.60 (0.36)
Maple	0	0	0	0	0	0	0	0	0	0	0	0
Sweetgum	0	0	0	-	-	0	0	-	0.56 (0.40)	0.50 (0.50)	0	-
Tulip poplar	0	-	-	-	-	-	-	-	1.86 (0.36)	-	-	-
Cypress	0	-	0.46 (0.26)	-	-	-	0.02 (0.02)	-	0	-	0.84 (0.32)	-
Oak	0.33 (0.33)	0	0	-	0.36 (0.31)	0.17 (0.17)	0	-	0.55 (0.28)	0	0	-
Beech	0	-	-	-	-	-	-	-	0	-	-	-
TOTAL	2.63 (1.59)	8.49 (7.56)	3.44 (2.00)	5.22 (1.27)	1.06 (0.50)	5.82 (2.07)	1.23 (0.79)	2.89 (0.51)	3.12 (0.58)	16.97 (5.37)	4.63 (1.89)	4.72 (0.84)

. . . continued/

Table 4. (continued)

SPECIES	March				May				July			
	MH	MG	CY	CE	MH	MG	CY	CE	MH	MG	CY	CE
Tupelo	0	0.54 (0.29)	0	-	0	0	0	-	0	0.08 (0.08)	0	-
Cedar	-	-	-	2.24 (0.28)	-	-	-	0.10 (0.06)	-	-	-	0
Black- gum	0	0.10 (0.07)	0.02 (0.02)	0	0	0	0	0	0	0	0	0
Maple	0.33 (0.16)	0.50 (0.30)	0.60 (0.33)	1.72 (0.33)	0.84 (0.24)	1.21 (0.29)	0.05 (0.03)	1.76 (0.36)	0	0	0	0
Sweet- gum	0.36 (0.36)	1.61 (1.19)	0.39 (0.39)	-	0	0	0	-	0	0	0	-
Tulip poplar	0.29	-	-	-	0.18 (0.07)	-	-	-	0	-	-	-
Cypress	0.04 (0.04)	-	0.40 (0.12)	-	0	-	0	-	0	-	0	-
Oak	0.04 (0.03)	0	0	-	0.04 (0.02)	0	0	-	0.01 (0.01)	0	0	-
Beech	0	-	-	-	0.20 (0.19)	-	-	-	0	-	-	-
TOTAL	1.06 (0.36)	2.75 (1.20)	1.41 (0.71)	3.96 (0.39)	1.26 (0.10)	1.21 (0.29)	0.05 (0.03)	1.86 (0.25)	0.01 (0.01)	0.08 (0.08)	0	0

"Cafeteria" Tests

The only fruits consumed during the cafeteria tests were those of tupelo gum, blackgum, oak and maple (Table 5). Not enough beech nuts were collected for analysis. Negligible amounts of cypress, cedar, tulip poplar, and sweetgum fruits and seeds were consumed, and the mice steadily lost weight, while the control mouse remained close to its original weight.

Tupelo and blackgum fruits, although consumed in quantity, failed to sustain the normal body weight in the experimental mice. Initial cafeteria tests, using rehydrated tupelo gum fruits, resulted in large weight losses after two days. There was also a considerable weight loss after two days on a blackgum fruit diet,

Table 5. Cafeteria test data for Peromyscus leucopus. Weight change data represent mouse 1, 2 and 3 (control), respectively. Weight changes of mice and food are in grams. Control mice were fed sunflower seeds.

MAST SPECIES	WEIGHT CHANGE (g)	PERCENT CHANGE	FOOD CONSUMED (g)
Tupelo	-5.24, -5.76, -2.12	-26.8%, -29.0%, -9.6%	12.14, 12.48, 2.57
Cedar	-3.45, -3.04, +0.52	-18.2%, -19.2%, +2.4%	0.00, 0.00, 6.80
Blackgum	-3.27, -3.06, -0.20	-17.6%, -16.3%, +1.1%	13.59, 13.83, 4.01
Maple	-0.25, -0.09, +0.29	-1.3%, -0.5%, +1.3%	4.80, 3.89, 5.21
Sweetgum	-2.72, -2.63, +0.09	-12.3%, -14.4%, +0.5%	0.02, 0.01, 3.07
Tulip poplar	-2.26, -2.54, +0.67	-10.2%, -13.6%, +4.1%	0.01, 0.08, 3.27
Cypress	-2.05, *, -0.20	-10.8%, *, -0.9%	0.05, *, 2.90
Oak	-0.06, -0.50, -0.11	-0.3%, -2.1%, -0.6%	3.02, 3.04, 3.08

\* Only enough cypress for two mice.

despite the consumption of large portions of these fruits. These results were unexpected because there was evidence that rodents had eaten both fruits in nature. Specifically, at the maple-gum stand, tupelo and blackgum fruits were found which had been gnawed to expose the cotyledon within the hard seed coat. The tupelo and blackgum tests were repeated, using fresh fruits, and it was observed that one mouse pierced through the tupelo gum fruit and seed coat to extract the cotyledon, but the other mouse did not. Both mice ate the fleshy part of the fruit. Each mouse lost over 10 percent of body weight after two days. The same pattern occurred with the blackgum fruits when a considerable weight loss was observed after two days. A comparison of the digestible

portions of the four edible fruits revealed the following: maple samaras are 75 percent digestible, acorns 43.6 percent, tupelo gum fruits 13 percent, and blackgum fruits only 0.1 percent digestible material.

### Flooding

In October 1979, the ground was dry at all four plant communities (Table 2). In May, the maple-gum and cedar communities were the most deeply flooded, followed by the cypress stand. In the mixed hardwood stand only an occasional shallow puddle was seen near the periphery of the community.

## DISCUSSION

Information obtained from three separate trapping sessions in the Dismal Swamp tends to support studies which have concluded that species diversity and density of small rodents in woodlands are among the lowest of all North American habitats (Dueser and Shugart 1978).

Data from Dismal Swamp rodent collections are available from 1895 to the present day, and have been tabulated and evaluated by Handley (1979). One of the more recent collections was his own made in February and June 1953. During a total of eight nights of trapping, Handley collected 34 P. leucopus, 14 O. nuttalli, one Reithrodontomys humulis, one Microtus pennsylvanicus, and three Mus musculus. Comparisons with the present study are difficult, because Handley's methods were not comparable, and he gave no information as to habitat or the size of the area he trapped. However, a similar hardwood swamp was trapped by Getz (1961), who captured six P. leucopus per 550 fall & winter trap nights. This figure is somewhat higher than my fall and winter findings. Getz also trapped an oak-hickory swamp, and trapped 32 P. leucopus in the same time frame.

Peromyscus leucopus is the most common and widespread mammal in the Dismal Swamp. It is equally at home in dry or wet situations, in forest and in brush. Populations of this species appear to fluctuate. Handley (1979) and others have found it in relatively high numbers. However, Dice (1940) found comparatively few when he snap-trapped in two upland brush areas, five areas in cypress swamp, and two near Lake Drummond in 1933 and 1935. The populations of white-footed mice then were evidently as low as in 1979-1980. Populations of white-footed mice also fluctuate by season. In Illinois, population density was highest during the autumn, but alternately declined and increased in the subsequent seasons (Batzli 1977). However, Batzli's floodplain population was more erratic than the upland population. In the Dismal Swamp, more mice were taken in the spring of 1979 than in the autumn, especially at the maple-gum stand. In the summer of 1980, no mice were found, which is in keeping with the tendency of white-footed mouse populations to decline in the summer.

Ochrotomys nuttalli is similar to the white-footed mouse in many aspects of its ecology and behavior. The golden mouse only occurs in the southern one-third of Virginia, and is much less common in the Dismal Swamp than is the white-footed mouse. Dueser and Shugart (1978) also found it to be comparatively rare. In a mesic forest at Oak Ridge, they captured a total of 167 P. leucopus in 9,696 summer trap nights compared to 12 O. nuttalli.

### Habitat/Mammal Relationships

#### Vegetation

Both mouse species found are nocturnal, territorial, and

arboreal {Baker 1968}. One of the major differences between them lies in the importance of microhabitat details. These details appear to be less vital to the white-footed mouse than to the golden mouse; Dueser and Shugart {1978} have called them microhabitat generalists and specialists, respectively.

Both ground cover and shrubs should be dense to support large numbers of these mice. M'Closkey and Lajoie {1975}, who examined the relationship between habitat structure and abundance of P. leucopus, found that mouse populations increased as the vegetation density of the 0-7.6 cm layer increased. This was attributed to a combination of factors such as food distribution, nesting sites, and complexity of escape routes.

The herbaceous layer at all four Dismal Swamp communities was quite sparse {Dabel and Day 1977}; its biomass was highest at the mixed hardwood stand {187.9 kg/ha}, and lowest at the maple-gum stand {25.7 kg/ha}. Cane [Arundinaria gigantea] is the principal herbaceous component at the mixed hardwood stand, but is probably neither tangled nor thick enough to provide an ideal habitat for either species of mouse. Ideal golden mouse sites have a dense ground cover and undergrowth of briars and vines {Goodpaster and Hoffmeister 1954; Blus 1966}.

The estimated biomass of the shrub layer at the cedar stand was high, 1851.9 kg/ha, compared to a low of 62.7 kg/ha at the cypress stand {Dabel and Day 1977}. The cedar stand contains a large number of fallen cedar trees, which provide excellent runways for the mice. M'Closkey {1975} and Getz {1961} have found a greater number of white-footed mice where there are fallen logs. In addition to runways, thick shrubs are essential as protection to small rodents against predators, especially raptors {Miller and Getz 1977}. The cedar stand contains appropriate shrubs and debris, which may in part explain why a few mice were found there in May and October 1979 {Table 2}. However, because of the larger numbers of white-footed mice found in the maple-gum stand in May 1979, it is clear that habitat is not the sole factor which influences P. leucopus density. Habitat does appear to exert a greater influence on the O. nuttalli populations, which is compatible with Dueser and Shugart {1978}, Goodpaster and Hoffmeister {1954}, and Linzey {1968}.

### Flooding

Although low numbers of mice were found, there is no indication that flooding directly decreases their densities. During May, the maple-gum and cedar communities were inhabited by a few mice, but in the dry, mixed hardwood stand, none was caught. Batzli {1977}, who compared populations of the white-footed mouse in floodplain and upland forests, found them to be similar in density at these locations. He observed no detrimental effects of flooding. Swimming tests using white-footed mice {Getz 1967, Sheppe 1965, Carter 1979} indicate that this mouse swims well, especially when it can clearly see its destination.

Paschal et al. {1979} concluded that inundation was not detrimental to nesting because they found larger numbers of white-footed mice in inundated areas of their Dismal Swamp study sites than in dry areas. In addition, they observed mice climbing and nesting in trees. Stah {1980} studied the vertical nesting distribution of white-footed mice under experimental conditions and found 17 of 26 mice elected to nest at heights of at least 77 cm, compared to 38.5 cm and ground level choices.

The nearly prehensile tail of the golden mouse is of great adaptive value to its arboreal existence. In addition, this mouse has a smaller hind foot than the white-footed mouse, which may make it an even better climber {Harper 1927}. Golden mice are

known to store seeds in their feeding platforms for future use {Goodpaster and Hoffmeister 1954}. It seems feasible that they could survive flooded swamp conditions; in this study, they swam well when released. Handley {1948} reported that this species is rarely found farther than 30 m from a body of water. Furthermore, the survival rate of this rodent during an east Texas flood, which lasted several weeks, was found to be 84 percent {Packard and Garner 1964}.

All other criteria being equal, perhaps the mice choose flooded areas as a defense strategy against predators. Whatever the case, it seems that these rodents are well adapted to flooded conditions, and there is no evidence that flooding reduces their population density, within the Swamp or elsewhere.

### Food Availability

The bulk of the food of white-footed mice is the mast of trees and shrubs, but they also consume grains and insects. They need to eat about 30 percent of their body weight each day {Hamilton 1941}. Food resources are known to influence numbers of white-footed mice, and several studies indicate a direct relationship between low mast production and low numbers of mice {e.g., Jameson, 1953}. Similarly, in the Dismal Swamp plant stands, mast production and numbers of white-footed mice both are low. In a study of red oak mast production, Hansen and Batzli {1977} considered  $173.3g\ m^{-2}\ yr^{-1}$  to be a high level, and  $14.0g\ m^{-2}\ yr^{-1}$  a low level of mast production. In this study  $1.32g\ m^{-2}\ yr^{-1}$  of acorns fell, which is only 9 percent of Hansen and Batzli's low figure. Secher Jensen {1975} found that winter reproduction in the bank vole {Clethrionomys glareolus} and the yellow-necked mouse {Apodemus flavicollis} failed to occur in Danish forests with low mast production, but did occur where mast was produced. This finding indicates the vital role of mast to forest-dwelling rodents.

Getz {1961} found that white-footed mice were more numerous in dry upland {oak-hickory} forests than in a low-lying swamp. However, Batzli {1977} found comparable densities in floodplain and upland forests. Batzli's study area comprised larger numbers of oaks and hickories, in both wet and dry sites, whereas these trees were only found in the drier upland areas of Getz' study sites. Both oak and hickory mast constituted a large proportion of the diet of this species {Getz 1961, Batzli 1977, Metzgar 1955}. Mast stored for future and emergency use is of obvious importance during flooded seasons in a swamp. By contrast, fruits such as those of the red maple {also present in Getz' swamp area} are less likely to be stored, due to their softer tissue and, their potential use is only seasonal {Getz 1961}.

Blus {1966} found the three major food items of the golden mouse to be small acorns, poison ivy seeds {Rhus radicans} and blackberries {Rubus spp.}. Goodpaster and Hoffmeister {1954} determined sumac {Rhus spp.}, wild cherry {Prunus spp.}, dogwood {Cornus spp.}, and greenbrier {Smilax spp.} seeds to be important food items.

Poison ivy and greenbrier are found at all four stands in the Dismal Swamp. Blackberries are found along the periphery of the cedar stand. As with the white-footed mouse, the lack of food which can be stored above flood levels for long periods of time appears to be a possible density-limiting factor for golden mice.

The literature on golden mice implies that this rodent is not such a generalist in its feeding habits as is the white-footed mouse. There is, for example, no indication that the golden mouse eats insects, as does the white-footed mouse.

In this study, maple fruits fell at all four stands, but only

fell at the cedar and maple-gum stands, which may have contributed to the higher number of white-footed mice found at these stands in May, and to the presence of golden mice at the cedar stand in May. Acorns were only found at the mixed hardwood stand, and in small quantities. The size of an acorn crop varies considerably every year; perhaps our collections were made in a year of low acorn production. Beech nuts are also edible, but too few were collected for the cafeteria tests. Like acorn production, the amount of beech mast varies annually. Secher Jensen (1975), who measured beech nut production in a Danish forest, characterized low mast production as less than  $5 \text{ g m}^{-2} \text{ yr}^{-1}$ .

With regard to mast production quantified in our study, a priori contrasting revealed significantly less mast at the mesic mixed hardwood stand than at the other stands. However, due to the enormous fluctuations in acorn and beech nut production, a ten year study, for example, might well show a reversal of the situation, with mast production of the mixed hardwood stand becoming significantly greater than that of the other stands.

A comparison of Tables 2 and 3 shows a potential correlation between the slightly larger numbers of white-footed mice at the maple-gum and cedar sites and the large total amounts of mast produced there. However, closer examination reveals little cause-and-effect relationship between mast production and mouse numbers. Maple fruits have already been mentioned as a possible, but temporary, cause for the higher numbers of mice at the cedar and maple-gum stands. The large amount of tupelo gum mast at the maple-gum stand is only a potential food source. A slight weight loss on an exclusive diet of a new food is not totally unexpected, but the weight loss of the mice fed gum fruits was considerable. Because of these weight losses, it seems that the energy expended by gnawing the tough seed coat to obtain the cotyledon outweighs the energy derived from that cotyledon. The mouse that did not attempt to gnaw the seed lost no more weight than those that did. The fleshy portions of the fruits are evidently indigestible, possibly because of the waxy component to the covering. In addition, if the gum fruits were used as food, one might have expected to find a greater density of mice in October than in May, especially at the maple-gum stand, which was not the case. It is worth noting the comparative amounts of digestible material in the four edible mast species. The amount in the gum species is negligible when compared to oak and maple, given the lack of digestible value of fleshy parts of the gum fruits.

In summary, there does not appear to be one single factor which limits the diversity and density of small rodents in the four Dismal Swamp plant communities. Diversity is predominantly affected by the flooded conditions which prevail throughout most of the Swamp. However, if flooding were the only factor limiting diversity, a greater variety of species would be expected at the mixed hardwood stand. This was not the case, so other factors appear to be involved.

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# Determination of the Smallest Size of a Sample Selected From A Finite Population for an Attribute with a Given Population Proportion

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## ABSTRACT

Mikhail, Lester and Weaver (1982a) have shown that the distribution of the sample percentage is very accurately approximated by a beta distribution,  $B(\alpha, \beta)$ , using a two-moment graduation. We have found that the parameters of the beta distribution,  $\alpha$  and  $\beta$ , depend only on the finite population size  $N$ , on the sample size  $n$ , and on a fixed value of population proportion.

In this paper, we have used the results illustrated in Tables 1.1, ..., 1.7 to determine the smallest size of a sample drawn without replacement from a finite population for an attribute with a given population proportion.

A comparison of Wolde-Tsadik's (1980, The American Statistician) results with our results is included.

## 1. INTRODUCTION

Mikhail, Lester and Weaver (1982a) have shown that in the case of a given finite population, the sampling distribution of a sample proportion is very accurately approximated by a beta distribution using a two-moment graduation. Furthermore, we have found that the beta model depends only on the finite population size  $N$ , and the sample size  $n$ , but not on the value of the population proportion  $P$ . It is noticed that the value of  $P$  is always constant and equal to  $3/10$ , and the computation for  $\beta_1$  (skewness) and  $\beta_2$  (kurtosis) for the actual distribution of sample proportion and for the beta distribution are depicted in Table 1, for different values of  $N$  and  $n$ , and  $P = 0.3$ . The chi-square model is found to fit very poorly.

## 2. THEORY

Given a sample of size  $n$  drawn without replacement from a finite population of size  $N$ , the first two moments (Mikhail, Lester and Weaver, 1982a) of the sample proportion are given by:

$$E(p) = P$$

$$\text{Var}(b) = \frac{P(1-P)}{n} \left( \frac{N-n}{N-1} \right)$$

### 2.1 The Beta Model

For a sample proportion of  $p$  of a sample size  $n$  drawn without replacement

from a finite population of size  $N$ , the beta distribution with parameters  $\alpha$ , and  $\beta$  is given by:

$$P \sim B(\alpha, \beta) \quad (2.1.1)$$

with the probability density function (p.d.f.)

$$f(p) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1} (1-p)^{\beta-1} \quad (2.1.2)$$

$$\text{Where } \Gamma(\alpha) = \int_0^\infty x^{\alpha-1} e^{-x} dx, \alpha > 0.$$

The first two moments of  $p$  are then

$$E(p) = \mu = \alpha/(\alpha+\beta)$$

$$\text{Var}(p) = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)} = \mu(1-\mu)/(\alpha+\beta+1). \quad (2.1.3)$$

Using the first two moments of section 2, we have

$$\alpha = \frac{N(n-1)}{(N-n)} P \quad (2.1.4)$$

$$\beta = \frac{N(n-1)}{(N-n)} (1-P).$$

For most of the values of  $N$ ,  $n$ , and  $p$ ,  $\alpha$  and  $\beta$  are integers, a fact which makes the usage of the beta model very practical for sample size  $n$ .

The values of  $\beta_1$  and  $\beta_2$  for the beta model are given in column II of Tables 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, and 1.7.

## 2.2 Chi-Square Model

Given the sample percentage  $p$  for a sample size  $n$  drawn without replacement from a finite population of size  $N$ , the scalar multiple of chi-square distribution with parameters  $\lambda$  and  $C$ , is given by,

$$p \sim C\chi_\lambda^2 \quad (2.2.1)$$

$$\text{or } p/C \sim \chi_\lambda^2$$

where  $\lambda$  stands for the degrees of freedom (d.f.)

The p.d.f. for this model is

$$f(\chi^2) = \frac{1}{2^{\lambda/2} \Gamma(\frac{\lambda}{2})} (\chi^2)^{\frac{\lambda}{2}-1} e^{-\chi^2/2}; 0 \leq \chi \leq \infty \quad (2.2.2)$$

with  $p/C$  as a chi-square variable.

The first two moments of  $p$  are

$$E(p) = C\lambda$$

$$\text{Var}(p) = 2C^2\lambda. \quad (2.2.3)$$

Using the first two moments of  $p$  in Section 2, we have

$$C = \left(\frac{1-P}{2n}\right) \left(\frac{N-n}{N-1}\right) \quad (2.2.4)$$

$$\lambda = \left(\frac{2nP}{1-P}\right) \left(\frac{N-1}{N-n}\right)$$

The values of  $\beta_1$  and  $\beta_2$  for the chi-square model are given in Column III of Tables 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 and 1.7. From the values of  $\beta_1 = \mu_3/\mu_2^{3/2}$  (skewness), and  $\beta_2 = \mu_4/\mu_2^2$  (kurtosis) in Tables 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, it is clear that the population proportion  $P = 0.3$ , gives a very good fit

of beta distribution to the actual distribution of sample percentage. The values of  $\beta_1$  and  $\beta_2$  in Column III for chi-square model is obviously showing a poor graduation to the actual distribution of sample proportion.

Accordingly, the estimated values of  $\alpha$  and  $\beta$  are reduced to the form of

$$\hat{\alpha} = 0.3 N(n-1)/(N-n)$$

$$\hat{\beta} = 0.7 N(n-1)/(N-n).$$

### 3. DETERMINATION OF THE SAMPLE SIZE

Consider the situation in which sampling units in the finite population of size  $N$  are divided into two mutually exclusive classes: class 1 consisting of units possessing the attribute under consideration with a given population proportion  $P$ , and class 2, consisting of those not possessing it.

Here we select a sample of size  $n$  from the finite population without replacement. From the beta model in section 2, we have:

$$\hat{\alpha} = 0.3N(n-1)/(N-n)$$

$$\hat{\beta} = 0.7N(n-1)/(N-n),$$

for which p.d.f. of beta distribution is determined. From this beta distribution, we select the value of the sample proportion  $p_{0.95}$  corresponding to the upper 5 percent level as an estimator of the population proportion  $P$  of the units possessing the attribute of class 1. This estimated value  $\hat{P} = p_{0.95}$ , will be regarded

TABLE 1.1: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS,  $N = 50$

	I	II	III
$S = 5$	$B1 = 1.15E-01$	$4.00E-01$	$1.71E+00$
$P = .3$	$B2 = 2.75E+00$	$2.71E+00$	$5.57E+00$
$S = 10$	$B1 = 3.65E-02$	$2.13E-01$	$7.62E-01$
$P = .3$	$B2 = 2.87E+00$	$2.88E+00$	$4.14E+00$
$S = 15$	$B1 = 1.23E-02$	$1.32E-01$	$4.44E-01$
$P = .3$	$B2 = 2.91E+00$	$2.93E+00$	$3.67E+00$
$S = 20$	$B1 = 2.70E-03$	$8.78E-02$	$2.86E-01$
$P = .3$	$B2 = 2.92E+00$	$2.95E+00$	$3.43E+00$
$S = 25$	$B1 = 0.00E+00$	$5.97E-02$	$1.90E-01$
$P = .3$	$B2 = 2.93E+00$	$2.97E+00$	$3.29E+00$
$S = 30$	$B1 = 2.70E-03$	$4.04E-02$	$1.27E-01$
$P = .3$	$B2 = 2.92E+00$	$2.98E+00$	$3.19E+00$

TABLE 1.2: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS,  $N = 75$

	I	II	III
$S = 5$	$B1 = 1.28E-01$	$4.08E-01$	$1.77E+00$
$P = .3$	$B2 = 2.75E+00$	$2.70E+00$	$5.65E+00$
$S = 10$	$B1 = 4.92E-02$	$2.26E-01$	$8.20E-01$
$P = .3$	$B2 = 2.88E+00$	$2.87E+00$	$4.23E+00$
$S = 15$	$B1 = 2.38E-02$	$1.48E-01$	$5.05E-01$
$P = .3$	$B2 = 2.92E+00$	$2.92E+00$	$3.76E+00$
$S = 20$	$B1 = 1.18E-02$	$1.05E-01$	$3.47E-01$
$P = .3$	$B2 = 2.93E+00$	$2.94E+00$	$3.52E+00$
$S = 25$	$B1 = 5.29E-03$	$7.81E-02$	$2.52E-01$
$P = .3$	$B2 = 2.94E+00$	$2.96E+00$	$3.38E+00$
$S = 30$	$B1 = 1.76E-03$	$5.93E-02$	$1.89E-01$
$P = .3$	$B2 = 2.95E+00$	$2.97E+00$	$3.28E+00$
$S = 35$	$B1 = 1.89E-04$	$4.56E-02$	$1.44E-01$
$P = .3$	$B2 = 2.95E+00$	$2.98E+00$	$3.22E+00$
$S = 40$	$B1 = 1.89E-04$	$3.52E-02$	$1.10E-01$
$P = .3$	$B2 = 2.95E+00$	$2.98E+00$	$3.17E+00$
$S = 45$	$B1 = 1.76E-03$	$2.70E-02$	$8.41E-02$
$P = .3$	$B2 = 2.95E+00$	$2.99E+00$	$3.13E+00$
$S = 50$	$B1 = 5.29E-03$	$2.03E-02$	$6.31E-02$
$P = .3$	$B2 = 2.94E+00$	$2.99E+00$	$3.09E+00$

\*s = sample size (n), and  $1.29E+01 = 1.29 \times 10^1$ .

TABLE 1.3: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS, N = 100

	I	II	III
S = 5 B1 = 1.34E-01	4.12E-01	1.79E+00	
P = .3 B2 = 2.75E+00	2.70E+00	5.64E+00	
S = 10 B1 = 5.58E-02	2.33E-01	8.48E-01	
P = .3 B2 = 2.88E+00	2.86E+00	4.27E+00	
S = 15 B1 = 3.02E-02	1.56E-01	5.34E-01	
P = .3 B2 = 2.92E+00	2.91E+00	3.80E+00	
S = 20 B1 = 1.77E-02	1.14E-01	3.77E-01	
P = .3 B2 = 2.94E+00	2.94E+00	3.57E+00	
S = 25 B1 = 1.05E-02	8.70E-02	2.83E-01	
P = .3 B2 = 2.95E+00	2.96E+00	3.42E+00	
S = 30 B1 = 5.98E-03	6.86E-02	2.20E-01	
P = .3 B2 = 2.96E+00	2.97E+00	3.35E+00	
S = 35 B1 = 3.11E-03	5.51E-02	1.75E-01	
P = .3 B2 = 2.96E+00	2.97E+00	3.26E+00	
S = 40 B1 = 1.31E-03	4.48E-02	1.41E-01	
P = .3 B2 = 2.96E+00	2.98E+00	3.21E+00	
S = 45 B1 = 3.17E-04	3.67E-02	1.15E-01	
P = .3 B2 = 2.96E+00	2.98E+00	3.17E+00	
S = 50 B1 = 4.19E-20	3.02E-02	9.43E-02	
P = .3 B2 = 2.96E+00	2.99E+00	3.14E+00	
S = 55 B1 = 3.17E-04	2.48E-02	7.71E-02	
P = .3 B2 = 2.96E+00	2.99E+00	3.12E+00	
S = 60 B1 = 1.31E-03	2.02E-02	6.22E-02	
P = .3 B2 = 2.96E+00	2.99E+00	3.09E+00	
S = .3 B2 = 2.96E+00	2.99E+00	3.08E+00	
S = 65 B1 = 3.11E-03	1.64E-02	5.08E-02	
P = .3 B2 = 2.96E+00	2.99E+00	3.08E+00	
S = 70 B1 = 5.98E-03	1.31E-02	4.04E-02	
P = .3 B2 = 2.96E+00	2.99E+00	3.06E+00	
S = 75 B1 = 1.05E-02	1.02E-02	3.14E-02	
P = .3 B2 = 2.95E+00	3.00E+00	3.05E+00	

TABLE 1.4: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS, N = 150

	I	II	III
S = 5 B1 = 1.40E-01	4.16E-01	1.82E+00	
P = .3 B2 = 2.75E+00	2.70E+00	5.72E+00	
S = 10 B1 = 6.26E-02	2.39E-01	8.77E-01	
P = .3 B2 = 2.88E+00	2.86E+00	4.32E+00	
S = 15 B1 = 3.69E-02	1.64E-01	5.64E-01	
P = .3 B2 = 2.92E+00	2.91E+00	3.85E+00	
S = 20 B1 = 2.41E-02	1.22E-01	4.07E-01	
P = .3 B2 = 2.94E+00	2.94E+00	3.61E+00	
S = 25 B1 = 1.66E-02	9.57E-02	3.13E-01	
P = .3 B2 = 2.95E+00	2.95E+00	3.47E+00	
S = 30 B1 = 1.17E-02	7.76E-02	2.51E-01	
P = .3 B2 = 2.96E+00	2.96E+00	3.38E+00	
S = 35 B1 = 8.24E-03	6.43E-02	2.06E-01	
P = .3 B2 = 2.96E+00	2.97E+00	3.31E+00	
S = 40 B1 = 5.77E-03	5.42E-02	1.72E-01	
P = .3 B2 = 2.97E+00	2.97E+00	3.26E+00	
S = 45 B1 = 3.95E-03	4.63E-02	1.46E-01	
P = .3 B2 = 2.97E+00	2.98E+00	3.22E+00	
S = 50 B1 = 2.59E-03	3.98E-02	1.25E-01	
P = .3 B2 = 2.97E+00	2.98E+00	3.19E+00	
S = 55 B1 = 1.59E-03	3.49E-02	1.08E-01	
P = .3 B2 = 2.97E+00	2.98E+00	3.16E+00	
S = 60 B1 = 8.64E-04	3.01E-02	9.40E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.14E+00	
S = 65 B1 = 3.75E-04	2.63E-02	8.19E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.12E+00	
S = 70 B1 = 9.25E-05	2.30E-02	7.16E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.11E+00	
S = 75 B1 = 1.43E-19	2.02E-02	6.26E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.09E+00	
S = 80 B1 = 9.25E-05	1.77E-02	5.48E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.07E+00	
S = 85 B1 = 3.75E-04	1.55E-02	4.79E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.07E+00	
S = 90 B1 = 8.64E-04	1.35E-02	4.18E-02	
P = .3 B2 = 2.98E+00	2.99E+00	3.06E+00	
S = 95 B1 = 1.59E-03	1.18E-02	3.63E-02	
P = .3 B2 = 2.97E+00	2.99E+00	3.05E+00	

TABLE 1.6: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS,  $N = 500$ 

	I	II	III
S = 10	$\beta_1 = 7.21E-02$	$\beta_1 = 2.48E-01$	$\beta_1 = 9.16E-01$
P = .3	$\beta_2 = 2.88E+00$	$\beta_2 = 2.85E+00$	$\beta_2 = 4.37E+00$
S = 20	$\beta_1 = 3.38E-02$	$\beta_1 = 1.33E-01$	$\beta_1 = 4.49E-01$
P = .3	$\beta_2 = 2.94E+00$	$\beta_2 = 2.93E+00$	$\beta_2 = 3.67E+00$
S = 30	$\beta_1 = 2.10E-02$	$\beta_1 = 8.99E-02$	$\beta_1 = 2.93E-01$
P = .3	$\beta_2 = 2.96E+00$	$\beta_2 = 2.95E+00$	$\beta_2 = 3.44E+00$
S = 40	$\beta_1 = 1.47E-02$	$\beta_1 = 6.71E-02$	$\beta_1 = 2.15E-01$
P = .3	$\beta_2 = 2.97E+00$	$\beta_2 = 2.97E+00$	$\beta_2 = 3.32E+00$
S = 50	$\beta_1 = 1.09E-02$	$\beta_1 = 5.30E-02$	$\beta_1 = 1.68E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.97E+00$	$\beta_2 = 3.25E+00$
S = 60	$\beta_1 = 8.39E-03$	$\beta_1 = 4.35E-02$	$\beta_1 = 1.37E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.21E+00$
S = 70	$\beta_1 = 6.60E-03$	$\beta_1 = 3.66E-02$	$\beta_1 = 1.15E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.17E+00$
S = 80	$\beta_1 = 5.27E-03$	$\beta_1 = 3.14E-02$	$\beta_1 = 9.82E-02$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.15E+00$
S = 90	$\beta_1 = 4.25E-03$	$\beta_1 = 2.73E-02$	$\beta_1 = 8.52E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.13E+00$
S = **	$\beta_1 = 3.45E-03$	$\beta_1 = 2.40E-02$	$\beta_1 = 7.48E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.11E+00$
S = **	$\beta_1 = 2.80E-03$	$\beta_1 = 2.13E-02$	$\beta_1 = 6.63E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.10E+00$
S = **	$\beta_1 = 2.27E-03$	$\beta_1 = 1.91E-02$	$\beta_1 = 5.92E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.09E+00$
S = **	$\beta_1 = 1.84E-03$	$\beta_1 = 1.72E-02$	$\beta_1 = 5.32E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.08E+00$
S = **	$\beta_1 = 1.47E-03$	$\beta_1 = 1.55E-02$	$\beta_1 = 4.81E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.07E+00$
S = **	$\beta_1 = 1.17E-03$	$\beta_1 = 1.41E-02$	$\beta_1 = 4.36E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.07E+00$

TABLE 1.5: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS,  $N = 250$ 

	I	II	III
S = 10	$\beta_1 = 6.80E-02$	$\beta_1 = 2.44E-01$	$\beta_1 = 9.00E-01$
P = .3	$\beta_2 = 2.88E+00$	$\beta_2 = 2.85E+00$	$\beta_2 = 4.35E+00$
S = 20	$\beta_1 = 2.96E-02$	$\beta_1 = 1.29E-01$	$\beta_1 = 4.31E-01$
P = .3	$\beta_2 = 2.94E+00$	$\beta_2 = 2.93E+00$	$\beta_2 = 3.65E+00$
S = 30	$\beta_1 = 1.69E-02$	$\beta_1 = 8.47E-02$	$\beta_1 = 2.75E-01$
P = .3	$\beta_2 = 2.96E+00$	$\beta_2 = 2.96E+00$	$\beta_2 = 3.41E+00$
S = 40	$\beta_1 = 1.06E-02$	$\beta_1 = 6.16E-02$	$\beta_1 = 1.97E-01$
P = .3	$\beta_2 = 2.97E+00$	$\beta_2 = 2.97E+00$	$\beta_2 = 3.30E+00$
S = 50	$\beta_1 = 6.94E-03$	$\beta_1 = 4.74E-02$	$\beta_1 = 1.50E-01$
P = .3	$\beta_2 = 2.97E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.22E+00$
S = 60	$\beta_1 = 4.57E-03$	$\beta_1 = 3.78E-02$	$\beta_1 = 1.19E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.18E+00$
S = 70	$\beta_1 = 2.96E-03$	$\beta_1 = 3.08E-02$	$\beta_1 = 9.64E-02$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.14E+00$
S = 80	$\beta_1 = 1.84E-03$	$\beta_1 = 2.56E-02$	$\beta_1 = 7.97E-02$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.12E+00$
S = 90	$\beta_1 = 1.05E-03$	$\beta_1 = 2.15E-02$	$\beta_1 = 6.66E-02$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.10E+00$
S = **	$\beta_1 = 5.14E-04$	$\beta_1 = 1.81E-02$	$\beta_1 = 5.62E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.08E+00$
S = **	$\beta_1 = 1.80E-04$	$\beta_1 = 1.54E-02$	$\beta_1 = 4.77E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.07E+00$
S = **	$\beta_1 = 1.98E-05$	$\beta_1 = 1.31E-02$	$\beta_1 = 4.06E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.06E+00$
S = **	$\beta_1 = 1.98E-05$	$\beta_1 = 1.12E-02$	$\beta_1 = 3.46E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.05E+00$
S = **	$\beta_1 = 1.80E-04$	$\beta_1 = 9.56E-03$	$\beta_1 = 2.95E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 3.00E+00$	$\beta_2 = 3.04E+00$
S = **	$\beta_1 = 5.14E-04$	$\beta_1 = 8.12E-03$	$\beta_1 = 2.50E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 3.00E+00$	$\beta_2 = 3.04E+00$

TABLE 1.7: VALUES OF  $\beta_1$  AND  $\beta_2$  FOR ACTUAL DISTRIBUTION AND DIFFERENT MODELS,  $N = 1000$ 

	I	II	III
S = 10	$\beta_1 = 7.41E-02$	$\beta_1 = 2.50E-01$	$\beta_1 = 9.25E-01$
P = .3	$\beta_2 = 2.88E+00$	$\beta_2 = 2.85E+00$	$\beta_2 = 4.39E+00$
S = 20	$\beta_1 = 3.59E-02$	$\beta_1 = 1.36E-01$	$\beta_1 = 4.58E-01$
P = .3	$\beta_2 = 2.94E+00$	$\beta_2 = 2.93E+00$	$\beta_2 = 3.69E+00$
S = 30	$\beta_1 = 2.32E-02$	$\beta_1 = 9.26E-01$	$\beta_1 = 3.02E-01$
P = .3	$\beta_2 = 2.96E+00$	$\beta_2 = 2.95E+00$	$\beta_2 = 3.45E+00$
S = 40	$\beta_1 = 1.68E-02$	$\beta_1 = 6.98E-02$	$\beta_1 = 2.24E-01$
P = .3	$\beta_2 = 2.97E+00$	$\beta_2 = 2.96E+00$	$\beta_2 = 3.34E+00$
S = 50	$\beta_1 = 1.30E-02$	$\beta_1 = 5.58E-02$	$\beta_1 = 1.78E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.97E+00$	$\beta_2 = 3.27E+00$
S = 60	$\beta_1 = 1.05E-02$	$\beta_1 = 4.63E-02$	$\beta_1 = 1.46E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.22E+00$
S = 70	$\beta_1 = 8.68E-03$	$\beta_1 = 3.95E-02$	$\beta_1 = 1.24E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.19E+00$
S = 80	$\beta_1 = 7.33E-03$	$\beta_1 = 3.43E-02$	$\beta_1 = 1.07E-01$
P = .3	$\beta_2 = 2.98E+00$	$\beta_2 = 2.98E+00$	$\beta_2 = 3.16E+00$
S = 90	$\beta_1 = 6.27E-03$	$\beta_1 = 3.02E-02$	$\beta_1 = 9.45E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.14E+00$
S = **	$\beta_1 = 5.43E-03$	$\beta_1 = 2.70E-02$	$\beta_1 = 8.41E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.13E+00$
S = **	$\beta_1 = 4.75E-03$	$\beta_1 = 2.43E-02$	$\beta_1 = 7.56E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.11E+00$
S = **	$\beta_1 = 4.18E-03$	$\beta_1 = 2.20E-02$	$\beta_1 = 6.85E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.10E+00$
S = **	$\beta_1 = 3.70E-03$	$\beta_1 = 2.01E-02$	$\beta_1 = 6.25E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.09E+00$
S = **	$\beta_1 = 3.29E-03$	$\beta_1 = 1.85E-02$	$\beta_1 = 5.74E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.09E+00$
S = **	$\beta_1 = 2.94E-03$	$\beta_1 = 1.71E-02$	$\beta_1 = 5.29E-02$
P = .3	$\beta_2 = 2.99E+00$	$\beta_2 = 2.99E+00$	$\beta_2 = 3.08E+00$

Table 2.1  
N = 20

$\alpha$	$\beta$	$\hat{p}$
12/17	28/17	0.85
18/16	42/16	0.70
24/15	56/15	0.64
30/14	70/14	0.60
36/13	84/13	0.58
42/12	98/12	0.52

Table 2.2  
N = 100

$\alpha$	$\beta$	$\hat{p}$
60/97	140/97	0.832
90/96	210/96	0.733
120/95	280/95	0.678
150/94	350/94	0.638
180/93	420/93	0.601
210/92	490/92	0.580
240/91	560/91	0.565
270/90	630/90	0.550
300/89	700/89	0.535



as the given population proportion for the selected sample units from the given finite population. These sample units will constitute the smallest size  $n$  of the sample drawn without replacement for a given attribute with a proportion  $\hat{P}$ .

In Tables 2.1 and 2.2, we give the values of sample size  $n$  selected from a finite populations of sizes  $N = 20$  and  $N = 100$ , for  $\hat{P} > 0.5$ , for units possessing the attribute of class 1.

For any values  $\hat{P} < 0.5$ , we will consider the units not possessing the attribute of class 2 with proportion  $\hat{Q} = 1 - \hat{P}$ .

#### 4. COMPARISON OF RESULTS

Wolde-Tsadik (1980) has determined the sample size based on the maximum length of the interval estimator of the correlation coefficient  $\rho$  when the parent population is normal.

He used David's Tables (1938) for this purpose. He also compared this method with two approximations. The first is that of Abramowitz and Stegun (1965), which is an approximation for the universe  $F$  function; the second is the  $Z$ -transformation of Fisher (1921). The results of Wolde-Tsadik indicate that the first approximation based on the maximum length of the interval estimator of the correlation  $\rho$  is as good as the second approximation and both of them are superior to Fisher's  $Z$ -transformation.

Mikhail, Prescott and Lester (1981), have shown that under normal assumption, Fisher's  $Z$ -transformation departs from normality very significantly, even for  $|\rho| > 0.3$ . This will explain why Fisher's  $Z$ -approximation in Wolde-Tsadik's (1980) results is inferior to the other methods.

Our method for the determination of the smallest size of a sample selected from a finite population of size  $N$  for an attribute with a given population proportion is based on the fact that distribution of the sample percentage is very accurately approximated by a beta model with two parameters,  $\alpha$  and  $\beta$ , which depend only on the population size ( $N$ ) and the sample size ( $n$ ).

Tables 2.1 and 2.2 illustrate the usefulness of this by listing  $\alpha$ ,  $\beta$ ,  $\hat{P}$  and  $n$  for two population sizes, showing the interdependence of  $n$  and  $\hat{P}$ .

Our method is clearly superior for the following reasons: first, Wolde-Tsadik used an infinite population while we are using finite populations which is more practical especially in biomedical experiments. Secondly, tables for beta distribution can be calculated easily for any  $\alpha$  and  $\beta$  to provide tables similar to 2.1 and 2.2 with adequate information about the sample sizes selected from a given finite population.

In the case of Wolde-Tsadik, more extensive calculation is involved to reach the same results.

#### 5. CONCLUSION

The values of  $\beta_1$  and  $\beta_2$  in Tables 1.1 - 1.7 show that the distribution of the sample percentage is very accurately graduated by a beta model. The fact is used to determine the smallest size of a sample drawn without replacement from a finite population. The reliability of the sample sizes given in Tables 2.1 and 2.2 depend on the prior knowledge of the population proportion of the attribute under consideration.

Tables similar to 2.1 and 2.2 can be easily calculated for different values of  $N$  and  $n$  using a beta distribution.

The more knowledge one has of the population proportion of that attribute, the more dependable the values of  $n$  given in Tables 2.1 and 2.2 or other calculated tables will be.

This makes our method relatively well suited to quality control analyses where the theoretical population proportion is arbitrarily fixed.

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## Virginia's Eminent Deceased Chemists<sup>1</sup>

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### ABSTRACT

The lives and achievements of sixty-five eminent deceased Virginia chemists are discussed. Thirty-four of the sixty-five were born or educated in Virginia, whereas the other thirty-one contributed to chemistry and chemical education while living in Virginia. Seventeen of the sixty-five died during the 19th Century, fifteen during 1901-1950, and thirty-three during 1951-1980.

### INTRODUCTION

It is appropriate in any discussion of Virginia's eminent deceased chemists and chemical engineers to start with the reminder that Virginia was the home of the first permanent English settlement in the Western Hemisphere, which was established at Jamestown, Va., in 1607. In early colonial days, Virginia's vast territory included much of today's eastern United States. Hence Virginia has a longer history than its sister states, and at one time was much larger in square miles than any other state. Virginia's long history and early territorial size might be partly responsible for the fact that seven of the first twelve presidents of the United States were Virginians.

Many of the presidents and other leaders from Virginia were knowledgeable or appreciative of science and engineering. Washington was a surveyor and engineer with a deep interest in scientific agriculture. Jefferson, a graduate of the College of William and Mary, had wide scientific interests. William Henry Harrison, the ninth president of the United States, attended Hampden-Sydney College and studied medicine. George Rogers Clark, a prominent Virginian, was a surveyor. Joseph R. Wilson, father of Woodrow Wilson, taught chemistry at Hampden-Sydney College. The climate was healthy for science in

---

<sup>1</sup>Based upon a talk given by the author before a meeting of the Division of History of the American Chemical Society in Atlanta, Ga., March, 1981.

Virginia very early in its history.

It seems appropriate now to look back and to pay tribute, however brief, to Virginia's eminent chemists who lived and died during the approximately 370 years since the Jamestown settlement. A Virginia chemist is herein defined as one who was born or educated in Virginia, or who contributed importantly to chemistry while living in Virginia. Deceased Virginia chemists were considered eminent if they were included in "American Chemists and Chemical Engineers," (Miles, 1976); designated "distinguished" in American Men of Science, 5th Ed., 1933; awarded important prizes and honors; and/or noted for outstanding performance as educators, researchers, inventors, authors, administrators, or business executives.

The challenge of presenting effectively information on sixty-five eminent deceased chemists is formidable. To facilitate the operation, the following plan was developed:

First, the individuals were categorized by periods:

- (1) Those individuals deceased during the 19th Century, or before the year 1901; (17)
- (2) Those deceased during the period 1901-1950; (15)
- (3) Those deceased during the period 1951-1980; (33)

Within these periods, the individuals were categorized as those who were (1) born in Virginia, (2) educated in Virginia, or (3) who lived in Virginia during a considerable part of their careers.

#### EMINENT DECEASED VIRGINIA CHEMISTS IN THE 19th CENTURY

Although there seems to be no record of eminent Virginia chemists in the 18th century, there were a considerable number in the 19th century.

Wyndham D. Miles's book entitled, "American Chemists & Chemical Engineers," (American Chemical Society, 1976) describes the careers of 17 eminent Virginia chemists who lived and died in the 19th century (Table 1). Several of these were particularly outstanding: J. P. Cushing, President, Hampden-Sydney College, 1821-35; H. Draper, M.D., recipient, Congressional Medal of Honor; J. W. Draper, M.D., President, Medical School, New York University, 1850-73; recipient, Rumford Medal, 1875; and first President of the American Chemical Society; R. M. Patterson, M.D., Director, Philadelphia Mint, 1835-51; W. B. Rogers, Founder and first President, Massachusetts Institute of Technology, 1865-82; J. L. Smith, President, American Chemical Society, 1877.

Four of the 17 eminent Va. chemists of the 19th century were born in Virginia's small towns and rural areas; four were born in Philadelphia; and five were born in Europe. Ten of the 17 had M.D. degrees (Table 1). P.K. Rogers, R.E. Rogers, Mitchell, and Patterson got their M.D.'s from the University of Pennsylvania; J. C. Draper and H. Draper from New York University; Smith from the University of South Carolina; J.B. Rogers from the University of Maryland; and J. W. Draper from Jefferson Medical College. De Chalmot had a Ph.D. from Göttingen. Four of the 17 (Patterson, 1828-35; W. B. Rogers,

Table 1. Eminent Chemists Born, Educated or "Careering" in Virginia in the 19th Century,  
a, b, c. Those with M.D. degrees are marked with an asterisk.

<u>By Birth</u>	<u>Birth</u>	<u>Education</u>	<u>Career</u>
Mitchell, John Kearsley (1793-1858)*	Shepperdstown, Va.	Univ. Pennsylv.	Jeff. Med.
Ruffin, Edmund (1794-1865)	Prince George Co., Va.	Wm. Mary	Soil expert, Va.
Draper, John Christopher (1835-85)*	Mecklinburg Co., Va.	New York Univ.	New York Univ.
Draper, Henry (1837-82)*	Prince Edward Co., Va.	New York Univ.	New York Univ.
<u>By Education</u>			
Rogers, James Blythe (1802-52)*	Phila., Pa.	Wm. Mary	Wash. Med.
Rogers, William Barton (1804-82)	Phila., Pa.	Wm. Mary	Wm. Mary; U.Va.
Rogers, Henry Darwin (1808-66)	Phila., Pa.	Wm. Mary	Univ. Pennsylv.
Rogers, Robert Emipie (1813-84)*	Baltimore, Md.	Wm. Mary	Univ. Va.
Smith, John Lawrence (1818-83)*	Charleston, S.C.	Univ. Va.	Univ. Va.
<u>By Career<sup>c</sup></u>			
Jones, Thomas P. (1773-48)*	England	?	Wm. Mary
Rogers, Patrick Kerr (1776-28)*	Ireland	Univ. Pennsylv.	Wm. Mary
Millington, John (1779-68)	England	Oxford	Wm. Mary
Patterson, Robert Maskell (1787-54)*	Phila., Pa.	Univ. Pennsylv.	Univ. Va.
Cushing, Jonathon Peter (1793-35)	Rochester, NH.	Dartmouth	Hamp. Syd.
Draper, John William (1811-82)*	England	Jeff. Med.	Hamp. Syd.
McCulloh, Richard Sears (1818-94)	Baltimore, Md.	Princeton	Wash. Lee
de Chalmot, Guillaume L.J. ( -1899)	Holland	Göttingen	Comm. Va.
<u>a.</u> From W.D. Miles, "American Chemists & Chemical Engineers," 1976, Am. Chem. Soc.			
<u>b.</u> More information about some of these chemists may be obtained from the following review: W.E. Trout, Jr., The Physical Sciences in Va., 1609-1900, Va. J. Sci. 27(4): 181-190 (1976).			
<u>c.</u> At least part of career was spent in Virginia, although some spent most of their career elsewhere (i.e., J.W. Draper at New York Univ.)			

1835-53; R. E. Rogers, 1842-52; and Smith, 1852-54) were professors at the University of Virginia. Four (Jones; P.K. Rogers, 1819-28; W. B. Rogers, 1828-35; and Millington, 1835) were professors at the College of William and Mary. Two (Cushing and J. W. Draper) were professors at Hampden-Sydney. One (R.S. McCulloh, 1866-77) was professor at Washington & Lee.

Three of the 17 early Virginia chemists became college presidents: Cushing, President of Hampden-Sydney, 1817-21; J.W. Draper, President, New York University Medical School, 1850-73; and W. B. Rogers, Founder and first President, M.I.T., 1865-82.

Seven of the 17 spent parts of their careers working for either the Federal or State governments; R. M. Patterson, Director, Philadelphia Mint; R. S. McCulloh, Chemist, U.S. Treasury Department; G.L.J. DeChalmot, Chemist, Commonwealth of Virginia; H.D. Rogers, Director, New Jersey Geological Survey; R. E. Rogers, Chemist, Pennsylvania Geological Survey; W. B. Rogers, Virginia State Geologist; and J. Millington, Director, Mississippi Geological Survey.

Two families, the Drapers and the Rogerses were conspicuous among the 17 early Virginia chemists. The three Drapers and the five Rogerses constitute almost 50% of the 17 eminent Va. chemists. John William Draper and his two sons, John Christopher and Henry, contributed greatly to 19th century science in the U.S. The father, born in 1811 near Liverpool, England, moved to Christiansville, Va., in 1832. He received the M.D. Degree from Jefferson Medical College in 1836. He was professor at Hampden-Sydney College, 1836-38; and at New York University, 1838-82. He was President of the Medical School of New York University from 1850-1873. He received the Rumford Medal of the American Academy of Arts and Sciences in 1875. He was the first president of the American Chemical Society.

John Christopher Draper (1835-85), son of John William Draper, received his M.D. from New York University in 1857. He served as professor at New York University and the College of the City of New York. He authored a textbook on medical physics.

Henry Draper (1837-82) emulated the examples of his father, John William, and his brother, John Christopher, by earning the M.D. degree. He was professor at New York University, 1860-82. He received the Congressional Medal of Honor and authored a "Textbook of Chemistry" in 1866.

Patrick Kerr Rogers (1776-1828), immigrant from Ireland, received the M.D. degree from the University of Pennsylvania Medical School in 1802. He was professor at the College of William and Mary from 1819 to 1828. Three of his four sons were born in Philadelphia (one in Baltimore) and received much of their education at the College of William and Mary.

The oldest son, James Blythe Rogers (1802-52), received the M.D. degree at the University of Maryland in 1822 and served as professor at the Washington Medical College, University of Cincinnati, and the University of Pennsylvania Medical School. He was chemist for the Virginia Geological Survey from 1837 to 1840.

The second son, William Barton Rogers (1804-82), was professor at the College of William and Mary, 1828-35, and the University of Virginia, 1835-53. He was State Geologist for the

Commonwealth of Virginia from 1835 to 1842. He was the principal founder and the first president of the Massachusetts Institute of Technology (1865-82)

The third son, Henry Darwin Rogers (1808-66), was professor at Dickinson College, Franklin Institute, University of Pennsylvania, and University of Glasgow. Before becoming professor at the University of Glasgow, he was Director of the New Jersey Geological Survey from 1836 to 1838.

The fourth son, Robert Empie Rogers (1813-84), received the M.D. degree from the University of Pennsylvania Medical School in 1836, thereby becoming the third holder of the M.D. degree in the Rogers Family. He was professor at the University of Virginia (1842-52), University of Pennsylvania Medical School (1852-77), and Jefferson Medical College (1877-84). He served also as chemist for the Pennsylvania Geological Survey, the Gas Trust of Philadelphia, and the U.S. Treasury Department.

Altogether, the 17 19th Century Virginia chemists had splendid records of achievement and provided excellent examples for later Virginians.

#### EMINENT VIRGINIA CHEMISTS DECEASED, 1901-1950

Given in Table 2 is information on 15 eminent chemists who died during the period 1900-1950 and who were born, educated, or "careered" in Virginia. Ten of these (Arbuckle, Baskerville, Bingham, Dabney, Kastle, Mallet, Meade, Reese, Venable, and Zeisberg) were listed in W. D. Miles's "American Chemists and Chemical Engineers." Some are listed in various editions of "American Men and Women of Science" and in similar compilations.

Of the 15 eminent Virginia chemists who died during 1900-1950, five were born in Virginia (Table 2); F. P. Venable, Prince Edward County; C. W. Dabney, Hampden-Sydney; E. W. Magruder, Albemarle County; R. K. Meade, Charlottesville; and W. C. Jones, Iron Gate. Three of the 15 were born in Baltimore, Md. Various other states and Ireland contributed one each.

The 15 eminent Virginia chemists who died during the period 1900-1950 received some or all their advanced education as follows: University of Virginia, 9; Hampden-Sydney, 3; Johns Hopkins, 2; and other schools one each. The ten who attended Virginia schools are: Dunnington, University of Virginia; Jones, VPI & SU, 1900; Venable, University of Virginia, 1879; Dabney, Hampden-Sydney, 1873, and University of Virginia, 1874-77; Reese, University of Virginia, 1884; Magruder, Hampden-Sydney and University of Virginia, 1891-92; Baskerville, University of Virginia; Arbuckle, Hampden-Sydney, 1890, and University of Virginia, 1895; Meade, University of Virginia, 1892-94; and Zeisberg, University of Virginia, 1906.

Six of these chemists spent at least a part of their careers on the faculty in Virginia colleges: Wilson, Hampden-Sydney, 1851-55; Mallet, University of Virginia, 1868-83; Dunnington, University of Virginia; Dabney, Emory and Henry; Kastle, University of Virginia, 1909-11; and Bingham, University of Richmond, 1906-15.

Four others also were employed in Virginia: Weems and Magruder, Virginia Department of Agriculture; Jones, Commonwealth of Virginia; and Meade, Longdale Iron Co.

Two were department chairmen in universities outside

Table 2. Eminent Chemists Born, Educated, or "Careering" in Virginia and Deceased 1901-1950<sup>a</sup>  
 An asterisk means the chemist was called "distinguished" by "American Men of Science" 1933

<u>By Birth</u>	<u>Birth</u>	<u>Education</u>	<u>Career</u>
*Venable, Frances Preston (1856-1934) <sup>b</sup> Dabney, Charles William (1859-1945) <sup>b</sup> Magruder, Egbert Watson (1868-1947) <sup>c,d</sup> Meade, Richard Kidder (1874-1930) <sup>b</sup> Jones, W. Catesby (1881-1944) <sup>c,e</sup>	Prince Edward Co., Va. Hampden-Sydney, Va. Albemarle Co., Va. Charlottesville, Va. Iron Gate, Va.	Univ. Va. Hamp. Syd., Univ.Va. Hamp. Syd., Univ.Va. Univ. Va. VPI & SU	U.N. Carolina Emory Henry Comm. of Va. Va. Industry Comm. of Va.
<u>By Education</u>			
*Dunnington, Francis Perry (1851-1944) *Reese, Charles Lee (1862-1940) <sup>b</sup> Arbuckle, Howard Bell (1870-1945) <sup>b</sup> *Baskerville, Charles (1870-1922) <sup>b</sup> Zeisberg, Frederick Clemens (1888-1938) <sup>b</sup>	Baltimore, Md. Baltimore, Md. Lewisburg, W.Va. Deer Brook, MS. Jefferson City, Mo.	Univ. Va. Univ. Va. Hamp. Syd., Univ.Va. Univ. Va. Univ. Va.	Univ. Va. dupont Davidson Col. U.N. Carolina dupont
<u>By Career</u>			
Wilson, Joseph R. (1822-1903) <sup>f</sup> *Mallet, John William (1832-1912) <sup>b</sup> Kastle, Joseph Hoeing (1864-1916) <sup>b</sup> Weems, Julius B. (1865-1930) <sup>c</sup> Bingham, Eugene Cook (1878-1945) <sup>b</sup>	Steubenville, Oh. Ireland Lexington, Ky. Baltimore, Md. Cornwall, Vt.	? Göttingen Johns Hopk. Clark Johns Hopk.	Hamp. Syd. Univ. Va. Univ. Va. Comm. of Va. Univ. Richmond
<p>a. Some had education or careers in two or more states.  b. W. D. Miles, "American Chemists &amp; Chemical Engineers," 1976, Am. Chem. Soc.  c. Private communication from J. W. Midyette, Jr.  d. Va. J. Sci. Proceedings, 1946-47, p. 45.  e. Va. J. Sci. Proceedings, 1944-45, p. 37.  f. J. M. Mulder, Woodrow Wilson, The Years of Preparation, Princeton University Press, 1978.</p>			

Virginia: Baskerville, Chairman of the Chemistry Department, University of North Carolina, 1900-04; and Bingham, Head of the Department of Chemistry & Metallurgy, Lafayette College, 1916-39.

Two of the 15 became college presidents: Dabney, President of both the University of Tennessee and the University of Cincinnati, 1904-20; and Venable, President of the University of North Carolina, 1900-14.

Four of the 15 were chief officers of state scientific societies: Baskerville, President, North Carolina Academy of Science; Jones, President, Virginia Academy of Science; Venable, Founder and first President, Elisha Mitchell Scientific Society, 1833; and Zeisberg, Chairman, Delaware Section, American Chemical Society.

Seven of the 15 occupied high positions in national or international scientific societies: Baskerville, Vice-President, American Association for the Advancement of Science, 1903; Dunnington, Secretary, Chemistry Section, Am. Assoc. Adv. Science; Mallet, President, American Chemical Society, 1882; Meade, Vice-President, American Institute of Chemical Engineers; Reese, Vice-President, International Union of Pure and Applied Chemistry; President, Manufacturing Chemists' Association, 1920-23; President, American Institute of Chemical Engineers, 1923-25; and President, American Chemical Society, 1934; Venable, President, American Chemical Society, 1905; and Zeisberg, President, American Institute of Chemical Engineers, 1938.

Four of the 15 advanced to high positions in industry: Magruder, Chief Chemist, F. S. Royster Guano Co., 1915-45; Meade, Chief Chemist, Edison Portland Cement Co., and General Manager, Tidewater Portland Cement Co.; Reese, Chief Chemist, New Jersey Zinc Co., and Chemist & Manager, E.I. duPont de Nemours & Co., 1902-31; and Zeisberg, Chemist & Manager, E.I. duPont de Nemours & Co.

Seven of the 15 held important positions in State organizations: Baskerville, Chemist, North Carolina Geological Survey; Dabney, Director, North Carolina Experiment Station; Jones, Chemist, Virginia Department of Agriculture, 1913-31, and Chief Chemist, Commonwealth of Virginia, 1931-44; Kastle, Director Kentucky Agricultural Experiment Station, and Dean, College of Agriculture, 1912-16; Magruder, Chief Chemist, Virginia Department of Agriculture, 1900-15; Mallet, Superintendent, Confederate States Ordinance Laboratory, 1862, and Weems, Chief Chemist, Virginia Department of Agriculture, 1915-30.

Three held positions in the following Federal establishments: Bingham, Physicist, U.S. Bureau of Standards, 1916; Dabney, Assistant Secretary, U.S. Department of Agriculture; and Kastle, Chief Chemist, U.S. Hygienic Laboratory, 1905-09.

#### EMINENT VIRGINIA CHEMISTS DECEASED 1951-80

A total of thirty-three eminent Virginia chemists are listed (Table 3) as having died during the period 1951-80. Eleven of these were born in Virginia and four others received at least some of their higher education in Virginia (Table 3). Eighteen others are categorized as Virginia chemists because substantial portions of their careers were spent in Virginia. Most of the thirty-three chemists listed in Table 3 received

Table 3. Eminent Chemists Born, Educated or Careering in Virginia and Deceased 1951-1980<sup>a</sup>

By Birth	Birth	Education	Career
Allison, Fred (1882-1974) <sup>b</sup>	Glade Spring, Va.	U.Va., Emory Henry	Auburn
Cox, Edwin (1902-1977) <sup>c</sup>	Richmond, Va.	VMI	V. Carol. Chem.
Gwathmey, Allan Talbott (1903-1963) <sup>d</sup>	Richmond, Va.	VMI, U.Va.	U.Va.
Jones, J. Claggett (1907-1965)	Roanoke, Va.	VPI & SU	Comm. of Va.
Potter, Thomas Willoughby, Jr. (1902-1972)	Floyd Co., Va.	Roanoke College	JBSC
Reid, E. Emmet (1872-1973) <sup>e</sup>	Fincastle, Va.	U. Richmond, John Hopk.	Johns Hopk.
Sherman, Henry Clapp (1875-1955) <sup>f</sup>	Ash Grove, Va.	Columbia	Columbia
Smith, Foley Foster (1905-1969)	Danville, Va.	U. Va.	Comm. of Va.
Trout, William E., Jr. (1903-1979) <sup>d</sup>	Clifton Forge, Va.	Johns Hopk.	U. Richmond
Veazey, William Reed (1883-1958) <sup>f</sup>	Chase City, Va.	Johns Hopk.	Case School
Watson, John Wilbur (1888-1962) <sup>d</sup>	Chatham, Va.	U.Va.	VPI & SU
By Education			
Bull, Fred Warren (1912-1979) <sup>c</sup>	Erwin, Tn.	VPI & SU	VPI & SU
Desha, Lucius Junius (1883-1967) <sup>d</sup>	Cynthiana, Ky.	Wash. Lee	Wash. Lee
Lind, Samuel Colville (1879-1965) <sup>f</sup>	McMinnville, Tn.	Wash. Lee	U. Minnes.
Sherrill, Mary Lura (1888-1968) <sup>f</sup>	Salisbury, N.C.	Randolph Macon	Mt. Holyoke
By Career			
Benton, Arthur Ferguson (1895-1979) <sup>b</sup>	Cranford, N.J.	Princeton	U. Va.
Chase, Harold Mason (1872-1960)	Lowell, Mass.	M.I.T.	Dan River Inc.
Detwiler, Samuel Bertollet, Jr. (1909-1978) <sup>d</sup>	Wabasha, Minn.	Geo. Wash.	USDA
Edgar, Graham (1887-1955) <sup>d</sup>	Fayetteville, Ark.	Yale.	U. Va.
German, Leslie (1909-1980) <sup>e</sup>	Dayton, Ky.	U. Cincin.	VMI
Gilreath, Esmark Senn (1904-1979) <sup>c</sup>	N. Wilkesboro, N.C.	U. No. Carolina	Wash. Lee
Guy, William George (1899-1969)	Carbonear, Newfoun.	U. Chicago	Wm. Mary
Hitchcock, Lauren Blakely (1900-1972) <sup>f</sup>	Paris, France	M.I.T.	U.Va.
*Howe, James Lewis (1859-1955) <sup>f</sup>	Newburyport, Mass.	Göttingen	Wash. Lee
Kupchan, S. Morris (1922-1976) <sup>c</sup>	New York, N.Y.	Columbia	U.Va.
Lutz, Robert Elliott (1900-1976) <sup>c</sup>	Boston, Mass.	Harvard	U.Va.
Major, Randolph Thomas (1901-1976) <sup>c</sup>	Columbus, Oh.	Princeton	U.Va.
Robey, Ashley (1903-1965) <sup>d,g</sup>	Fort Worth, Tx.	Cornell	Roanoke Col.
Scherer, Philip Carl (1893-1960) <sup>d</sup>	Brooklyn, N.Y.	Brown	VPI & SU
Scribner, Allison Kenneth (1898-1976)	Boston, Mass.	Harvard	Va. Chemicals
Small, Lyndon Frederick (1897-1957) <sup>f</sup>	Allston, Mass.	Harvard	U.Va.
Vilbrandt, Frank Carl (1893-1960) <sup>d</sup>	Fostoria, Oh.	Ohio State	VPI & SU
Yoe, John Howe (1892-1978) <sup>c,e</sup>	Oxford, Ala.	Princeton	U.Va.

a. Some had education and careers in two or more states; an asterisk means the chemist was called "distinguished" by American Men of Science, 1933; JBSC is Journal Box Servicing Corp.

b. American Men & Women of Science, 1977.

c. Who's Who in America 1975.

d. American Men of Science, 1949.

e. World's Who's Who in Science, 1968.

f. W. D. Miles, "American Chemists & Chemical Engineers", 1976, Am. Chem. Soc.

g. Chemical Who's Who, 1951.

earned Ph.D. degrees. Some of the schools that awarded the degrees are the University of Virginia (4), Harvard (3), Johns Hopkins (3), and Princeton (3).

Most of the 33 chemists achieved eminence in academic institutions. Three chemists (Cox, Potter, and Scribner) were unusually successful in industrial careers. Six chemists (Reid, Sherman, Veazey, Lind, Hitchcock and Small) had careers both in academia and industry or in academia and government. Detwiler and Jones pursued careers in Federal and State government, respectively. Smith worked both for industry and the Commonwealth of Virginia.

Several of the 1951-80 deceased chemists were elected to high offices in national or state technical societies: S.C. Lind, President, American Chemical Society, 1940; R. T. Major, Board of Directors, American Chemical Society, 1955-60; W. R. Veazey, President, Electrochemical Society, 1946; Leslie German, Chairman, Virginia Blue Ridge Section, Am. Chem. Soc., 1950; A.T. Gwathmey, President, Virginia Academy of Science, 1954; and F. F. Smith, Chairman, Virginia Section, Am. Chem. Soc., 1946,



and President, Va Academy of Science.

The following reached high positions in academia: Fred Allison, Dean, Graduate School, Alabama Polytechnic Institute, and Director, Auburn Research Foundation, 1949; F. W. Bull, Department Head, VPI & SU, 1965-78; Dean, Graduate School, VPI & SU, 1965-78; L. J. Desha, Dean, Washington & Lee, 1946; S. C. Lind, Chief Chemist, U.S. Bureau of Mines, 1923-25; Dean, Institute of Technology, Univ. of Minnesota, 1935-47; A.F. Benton, Department Chairman, University of Virginia, 1928; Leslie German, Department Head, Va. Military Institute, 1942; E. S. Gilreath, Department Head, Washington & Lee, 1946-70; W. G. Guy, Department Head, College of William & Mary, 1946-68; R. E. Lutz, Department Head, U. of Va., 1951-53; Ashley Robey, Department Head, Roanoke College, 1941-65; Mary L. Sherrill, Department Head, Mt. Holyoke, 1946-54; W. R. Veazey, Department Head, Case School of Applied Sciences; Board of Trustees, Westminster College; Director, Dow Chemical Co., Vice President, Dowell, Inc., Director, Dow Corning Corp; F.C. Vilbrandt, Department Head, U. of No. Carolina, 1927-30; Department Head, VPI & SU, 1935; J. W. Watson, Department Head, VPI & SU, 1925; and J. H. Yoe, Department Head, U. of Va., 1953-57.

These reached high positions in industry: H. M. Chase, Director of Research, Dan River, Inc.; Edwin Cox, Vice President, Va. Carolina Chemical Corp., 1949-57; President, Tobacco Byproducts and Chemical Corp; Graham Edgar, Research Director, Ethyl Corp., 1924-32; Vice President, Ethyl Corp., 1932; Vice President, Ethyl Dow Chemical Co., 1934; L. B. Hitchcock, President, Los Angeles Air Pollution Foundation, 1954-57; R. T. Major, Vice President and Scientific Director, Merck & Co., 1947-53; T. W. Potter, Vice President, Journal Box Servicing Corp., 1940-68; A. K. Scribner, Vice President, 1950, President, 1957, Va. Chemicals; Director, Norfolk, Franklin & Danville Railroad.

The following were important in State and Federal government: S. B. Detwiler, Jr., Technical Program Specialist, Agricultural Research Service, U.S. Department of Agriculture, 1953-72; H. C. Sherman, Chief, Bureau of Human Nutrition, U.S. Department of Agriculture; L. F. Small, Research Specialist, National Institutes of Health, and L. F. Small, Director, Drug Addiction Laboratory, U. of Va.

From the foregoing, it is clear Virginians have reason to be proud of its chemists beginning in its early history and continuing today. The large volume and high quality of current chemical research in Virginia give assurance there will be ample justification for pride in the future.

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**Degree of Aflatoxin B<sub>1</sub> Sensitivity  
in Virginia Natural Populations  
of *Drosophila Melanogaster***

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**ABSTRACT**

Natural populations of *Drosophila melanogaster* were sampled from counties in Virginia reporting aflatoxin contamination of corn and peanut crops and from Virginia counties reporting no aflatoxin contamination. Eggs from each population sample were placed on media containing 0.0, 0.5, and 1.0 ppm aflatoxin B<sub>1</sub> (AFB<sub>1</sub>). Data on egg-pupal and egg-adult development times, egg-pupal and egg-adult viability, and the sex and body lengths of adults were collected to determine the relative degrees of resistance of these samples to AFB<sub>1</sub> induced toxicity. Flies sensitive to AFB<sub>1</sub> show decreased viability, smaller adult body sizes, and significant elongation of development times. There appears to be significant variation in resistance to AFB<sub>1</sub> among the populations correlating with the areas from which the flies were collected. In general, flies from aflatoxin contaminated areas are more resistant to AFB<sub>1</sub> toxicity than flies from aflatoxin free areas. Natural selection may be responsible for this correlation. Chromosome substitution analysis indicated that factors on chromosomes two and three provide increased resistance to AFB<sub>1</sub>, while X-linked factors enhance sensitivity.

**INTRODUCTION**

Aflatoxins are a group of secondary metabolites produced by certain strains of the fungi *Aspergillus flavus* and *A. parasiticus*. Chemically, the aflatoxins are highly oxygenated heterocyclic compounds that contain the bisfuran moiety, either as the dihydrofuran system, as in aflatoxins B<sub>1</sub> and G<sub>1</sub> (AFB<sub>1</sub>, AFG<sub>1</sub>) or as the tetrahydrofuran system, as in AFB<sub>2</sub> and AFG<sub>2</sub> [Ciegler and Bennett, 1980].

The prolific *A. flavus* is ubiquitous in the soil and air in many parts of the world [Detroy et al., 1971; Raper and Fennell, 1973]. Not all strains of *A. flavus* are capable of toxin production; however, reliable evidence indicates that a major proportion of isolates encountered are aflatoxin producers, with the most common toxin produced being AFB<sub>1</sub> [Stoloff, 1977]. Although *A. flavus* is usually classified as a storage mold of agricultural products, it also can contaminate crops in the field or orchard, particularly in the warmer, more humid growing regions of the

world [Anderson *et al.*, 1975; Hesselstine *et al.*, 1976]. Some of the agricultural products known to be contaminated with aflatoxin in significant amounts and incidence include peanuts, corn, grain sorghum, millet, cottonseed, copra, and figs [Stoloff, 1977].

Plant stress caused by drought appears to be a contributing factor to the invasion of corn and peanut crops by *A. flavus* and the subsequent production of aflatoxin [Dickens, 1977; Lillehoj and Hesselstine, 1977]. A drought-wet sequence in climatic conditions in 1977 was believed to contribute to aflatoxin contamination of corn crops in certain areas of Virginia [Llewellyn and Katzen, 1981]. Following another severe drought in Virginia during the 1980 growing season, abnormally high levels of aflatoxin were reported in corn crops, especially in the southeastern portion of the state; and a large percentage of the peanuts harvested in drought-stricken areas of Virginia also was contaminated with aflatoxin. Well distributed and seasonally abundant rainfall and moderate temperatures were believed to be factors in the low infestation of peanut kernels and shells in three peanut growing states in 1964 [Diener *et al.*, 1965].

Attack of plants by insects, which often increases during periods of drought [Lillehoj and Hesselstine, 1977], may also contribute to aflatoxin contamination. A 1977 survey of corn samples from North Carolina showed that, in general, the higher the percentage of insect-damaged corn, the higher the level of aflatoxin [Hesselstine *et al.*, 1981]. Anderson *et al.* [1975] observed insect damage in 90% of the corn samples that were contaminated with aflatoxin.

Aflatoxin B<sub>1</sub> (AFB<sub>1</sub>) is highly mutagenic in a wide variety of organisms [Ong, 1975; Wong and Hsieh, 1976] and highly carcinogenic among vertebrates of many classes [Newberne and Butler, 1969; Patterson, 1973; Wogan, 1977]. Among invertebrates, especially insects, dietary AFB<sub>1</sub> has insecticidal, larvicidal, and chemosterilizing properties [Lalor *et al.*, 1976].

Various wild-type strains of the fruit fly *Drosophila melanogaster* differ in their responses to AFB<sub>1</sub> placed in the culture medium in which the larvae develop from the egg stage. Toxicity is demonstrated by reduced larval and pupal viability, a reduction in the length of the pupal cases and the adult flies, and an increase in the egg-to-pupal and egg-to-adult development times [Lalor *et al.*, 1976; Chinnici *et al.*, 1976]. On the basis of these criteria, several wild-type laboratory strains of *D. melanogaster* are quite sensitive, and others are relatively resistant [Llewellyn and Chinnici, 1978]. Strains relatively resistant to AFB<sub>1</sub> damage must be exposed to double or triple the dose given to a sensitive strain before similar levels of toxicity are expressed.

The only detailed genetic analysis of the control of resistance to AFB<sub>1</sub> toxicity has been performed using *D. melanogaster*. Chromosome substitution analysis of laboratory strains has shown that the toxic variation is due to autosomal gene differences [Chinnici, 1980]. The present study was undertaken to determine whether the unusually high levels of aflatoxin in the natural environment of parts of Virginia in 1980 had any effect on the AFB<sub>1</sub>-resistance levels of natural populations of *D. melanogaster* in these areas. Population samples taken both from counties with aflatoxin-contaminated corn and/or peanut crops and from counties without aflatoxin contamination were tested in the laboratory for degree of resistance to dietary AFB<sub>1</sub>. Chromosome substitution analysis was then used to investigate the genetic basis for variation in level of resistance to AFB<sub>1</sub>.

### Collecting Flies

Samples of natural Drosophila melanogaster populations were collected in the Fall of 1980 from seven counties (25 samples) in Virginia reported by the Virginia Department of Agriculture to have high aflatoxin contamination of corn and/or peanut crops. Collections were also made in seven counties (15 samples) reported to have little or no aflatoxin contamination. Table 1 lists and briefly describes all 40 sites.

Quart size mason jars with a nylon net covering to keep out larger insects were used as traps to collect the flies. A banana and yeast mixture was placed in the bottom of the jars as bait. Traps were placed on the ground in locations where fruit flies were most likely to be exposed to A. flavus and/or aflatoxin (i.e. peanut warehouses; peanut, corn, soybean fields) and, where possible, orchards and dumpsters adjacent to corn or peanut fields. The traps were left in place for several hours after which the jars containing flies were sealed with a piece of cloth and transported to the laboratory. Flies were allowed to lay eggs in the traps and the parents and offspring were transferred to half-pint culture bottles containing standard culture medium. They were allowed to reproduce until a sufficient number of flies were available for experimentation.

### Media

The culture medium used was a mixture of yeast, dextrose, and agar with several inorganic salts. Tegosept was added to inhibit mold growth. Aflatoxin B<sub>1</sub> (Grade A. Calbiochem, La Jolla, Calif.) dissolved in 10 ml of acetone was used to make a stock solution of 10 ppm AFB<sub>1</sub>. Equivalent amounts of acetone were added to the control medium (0.0 ppm AFB<sub>1</sub>). The stock solution and control medium were used to make dilutions of 0.5 and 1.0 ppm AFB<sub>1</sub>. The control and AFB<sub>1</sub> supplemented media were poured into 8 dram glass shell vials, stoppered with foam plugs, and refrigerated until used.

### Experimental Procedures

1. Testing for AFB<sub>1</sub> sensitivity. Flies from each of the 40 samples were allowed to lay eggs for 12 hours in half-pint culture bottles containing control medium. The eggs were then collected and groups of 25 were placed on small squares of blotting paper moistened with distilled water. Each square with 25 eggs was placed in a separate 8 dram glass shell vial containing medium supplemented with either 0.0, 0.5, or 1.0 ppm AFB<sub>1</sub>. The vials were incubated at  $25 \pm 1^\circ\text{C}$ . Each treatment was replicated six times. As the cultures developed, data were collected daily on egg-pupal and egg-adult development times, egg-pupal and egg-adult viability, and the sex and body length of adults.

2. Chromosome substitution analysis. The results of the sensitivity tests were used to select a natural Drosophila population that was relatively insensitive (resistant) to the toxic effects of AFB<sub>1</sub> (\*in Table 1) and a relatively sensitive population (\*\*in Table 1). The chromosome substitution technique of Seiger, [1966], was used to mate these flies with Complete Multiple Inversion (CMI) stock flies generously provided by Dr. T. R. F. Wright of the University of Virginia. The CMI stock contains multiply inverted X (FM6), second (SM5) and third (TM3) chromosomes, and noninverted second (Sp bw<sup>D</sup>) and third (Sb) chromosomes so that a CMI female has the balanced karyotype FM6/FM6; SM5/Spbw<sup>D</sup>; TM3/Sb. All second and

Table 1. Virginia counties (contaminated or uncontaminated with *A. flavus* and aflatoxin) and collecting sites, and the effect of larval growth in aflatoxin B<sub>1</sub> supplemented media on viability to the adult stage.

Counties and Collecting Sites	number of adults ( $\bar{x} \pm \text{SEM}$ ) <sup>a</sup>		
	0.0 ppm <sup>b</sup>	0.5 ppm	1.0 ppm
<u>Southampton</u> (contaminated)			
1. Apple orchard near peanut and corn fields	22.33 $\pm$ 0.51	19.17 $\pm$ 1.09	13.00 $\pm$ 1.51
2. Peanut warehouse trash can	19.50 $\pm$ 0.39	18.33 $\pm$ 1.22	11.67 $\pm$ 1.10
3. Pear tree near peanut and corn fields	20.17 $\pm$ 0.76	12.33 $\pm$ 1.31	5.50 $\pm$ 1.39
4. Peanut sheller shell heap	19.17 $\pm$ 0.72	13.83 $\pm$ 1.07	13.67 $\pm$ 1.12
5. In soybean field	19.83 $\pm$ 0.44	11.83 $\pm$ 1.23	5.83 $\pm$ 1.52
6. Nursery tomato plants	21.33 $\pm$ 0.69	18.00 $\pm$ 0.67	12.67 $\pm$ 1.12
7. Peanut sheller near pokeberries	16.83 $\pm$ 0.72	11.00 $\pm$ 2.03	5.75 $\pm$ 1.43
8. Apple trees near corn fields	21.83 $\pm$ 1.21	19.00 $\pm$ 1.29	12.17 $\pm$ 1.69
9. Public dumpsters	9.50 $\pm$ 0.99	9.17 $\pm$ 0.93	8.33 $\pm$ 0.31
10. In soybean field	23.00 $\pm$ 0.33	16.00 $\pm$ 0.62	8.17 $\pm$ 0.86
11. In soybean field	21.33 $\pm$ 0.39	18.33 $\pm$ 0.84	5.17 $\pm$ 0.80
<u>Prince George</u> (contaminated)			
12. Apple tree in corn field	22.50 $\pm$ 0.87	15.50 $\pm$ 0.74	9.67 $\pm$ 1.52
13. Peanut and soybean field	22.00 $\pm$ 0.47	18.83 $\pm$ 1.04	8.50 $\pm$ 1.12
14. Nursery near pumpkins	22.83 $\pm$ 1.12	17.50 $\pm$ 1.35	11.50 $\pm$ 1.12
15. Pear tree near peanut and corn fields	20.17 $\pm$ 0.90	17.80 $\pm$ 1.34	5.17 $\pm$ 0.80
16. Pear tree near peanut field	22.67 $\pm$ 0.73	17.67 $\pm$ 1.07	9.33 $\pm$ 0.90
<u>Isle of Wight</u> (contaminated)			
17. Pumpkin patch	20.17 $\pm$ 1.40	15.33 $\pm$ 1.02	11.00 $\pm$ 0.94
18. In soybean field	21.83 $\pm$ 0.49	10.67 $\pm$ 0.77	5.17 $\pm$ 0.76
19. In soybean field	21.67 $\pm$ 0.77	12.33 $\pm$ 1.45	5.50 $\pm$ 0.74
<u>Surry</u> (contaminated)			
20. Public dumpsters	20.17 $\pm$ 0.83	13.67 $\pm$ 1.12	7.00 $\pm$ 0.74
21. In soybean field	19.50 $\pm$ 0.39	1.50 $\pm$ 0.46	0
<u>Sussex</u> (contaminated)			
22. In soybean field	23.17 $\pm$ 0.90	17.00 $\pm$ 0.47	8.83 $\pm$ 1.23
23. Apple tree and soybean field near peanut processor*	20.50 $\pm$ 0.51	16.33 $\pm$ 1.05	14.83 $\pm$ 0.95
<u>Nottoway</u> (contaminated)			
24. Apple and pear orchard	17.17 $\pm$ 0.37	9.83 $\pm$ 1.14	5.33 $\pm$ 0.73
<u>Franklin</u> (contaminated)			
25. Apple orchard	20.50 $\pm$ 0.84	16.83 $\pm$ 1.04	12.17 $\pm$ 0.86
<u>Chesterfield</u> (uncontaminated)			
26. Apple orchard	23.00 $\pm$ 0.78	19.33 $\pm$ 0.84	9.00 $\pm$ 1.11
27. Apple orchard	15.67 $\pm$ 0.73	7.00 $\pm$ 0.88	0.50 $\pm$ 0.46
28. Apple tree	22.67 $\pm$ 0.39	14.83 $\pm$ 0.76	4.17 $\pm$ 0.80
29. Apple orchard	20.50 $\pm$ 1.41	13.83 $\pm$ 1.16	5.50 $\pm$ 0.94

Table 1. (continued)

Counties and Collecting Sites	number of adults ( $\bar{x} \pm \text{SEM}$ ) <sup>a</sup>		
	0.0 ppm <sup>b</sup>	0.5 ppm	1.0 ppm
<u>Rockingham (uncontaminated)</u>			
30. Apple orchard **	15.67 $\pm$ 0.31	8.33 $\pm$ 0.45	1.67 $\pm$ 0.39
31. Apple orchard	16.83 $\pm$ 0.98	5.00 $\pm$ 1.05	1.67 $\pm$ 0.39
32. Apple orchard	10.83 $\pm$ 0.72	6.33 $\pm$ 1.02	2.33 $\pm$ 0.39
33. Apple orchard	18.17 $\pm$ 1.19	17.00 $\pm$ 1.39	15.17 $\pm$ 1.30
<u>Albermarle (uncontaminated)</u>			
34. Apple orchard	18.67 $\pm$ 0.90	15.67 $\pm$ 1.48	7.00 $\pm$ 1.20
35. Apple orchard	22.17 $\pm$ 0.28	16.33 $\pm$ 1.28	10.17 $\pm$ 1.32
<u>Roanoke (uncontaminated)</u>			
36. Apple trees	19.50 $\pm$ 0.99	6.67 $\pm$ 0.61	0.83 $\pm$ 0.44
37. Apple trees	19.67 $\pm$ 0.81	12.50 $\pm$ 1.31	7.17 $\pm$ 1.36
<u>Augusta (uncontaminated)</u>			
38. Apple orchard	20.00 $\pm$ 0.41	9.67 $\pm$ 0.90	2.33 $\pm$ 0.56
<u>Botetourt (uncontaminated)</u>			
39. Apple orchard	15.17 $\pm$ 0.80	9.00 $\pm$ 1.05	4.50 $\pm$ 0.51
<u>Prince Edward (uncontaminated)</u>			
40. Pear orchard	14.50 $\pm$ 1.31	14.83 $\pm$ 1.35	13.67 $\pm$ 2.18

a. Each treatment was replicated 6 times. Each vial initially contained 25 eggs.

b. ppm AFB<sub>1</sub> in the culture medium.

\*RX23, resistant strain used in the chromosome substitution analysis.

\*\*SX23, sensitive strain used in the chromosome substitution analysis.

third chromosomes are recessive lethals. Mating schemes similar to those described previously [Chinnici 1971, 1980] were used to produce strains with known combinations of chromosomes from a resistant (RX23) and a sensitive (SX23) natural population. Figure 1 gives the chromosome constitutions of the substituted strains thus produced.

3. To test the hypothesis that presence or absence of aflatoxin in the environment has an effect on the sensitivity of natural populations to AFB<sub>1</sub> induced toxicity, the 40 fruit fly populations were categorized into two groups: those collected from aflatoxin-contaminated areas and those collected from aflatoxin-free areas. Variables (adult viability, development times, etc) from each group were compared and tested for significant differences using analysis of variance.

## RESULTS

### Sensitivity levels of the natural populations

Analysis of the data showed that for each level of AFB<sub>1</sub> treatments (0.0, 0.5, and 1.0 ppm), considerable variation existed among the 40 natural populations in egg-pupal and egg-adult viabilities, egg-pupal and egg-adult development times and body lengths of adult males and females. Data for egg-adult viabilities are given in Table 1 and graphed in Figure 2.



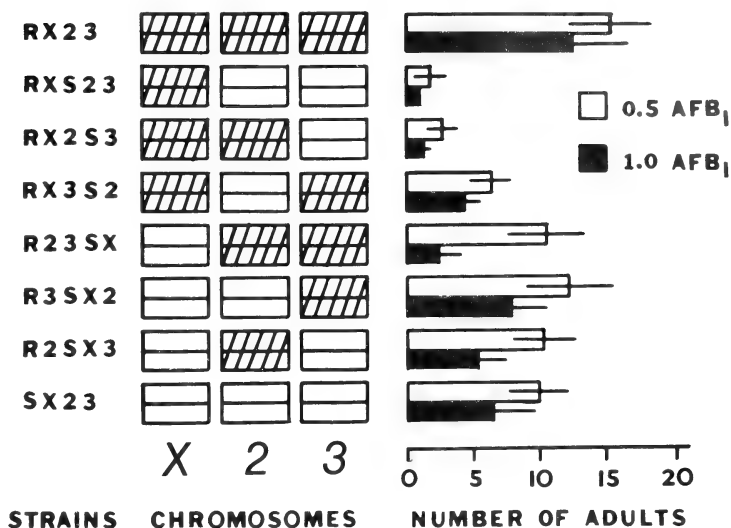


Fig. 1.

Chromosome substitution study. Chromosome content of each substituted strain and the mean number of adults ( $\pm$  SEM) for 6 replications starting with 25 eggs each are given for 0.5 ppm AFB<sub>1</sub> and 1.0 AFB<sub>1</sub> treatments. Chromosomes derived from the resistant strain (RX23) are shown crosshatched, and those from the sensitive strain (SX23) as open rectangles.

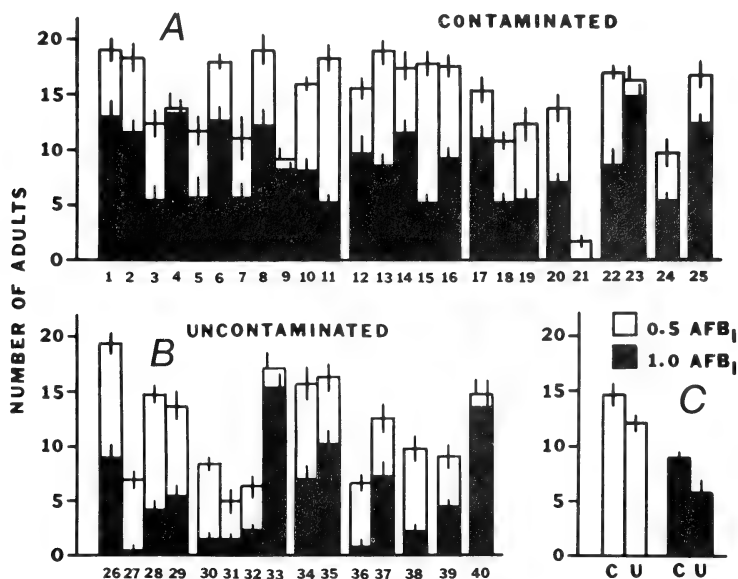


Fig. 2.

Mean  $\pm$  SEM values for six replications of 0.5 ppm AFB<sub>1</sub> and 1.0 ppm AFB<sub>1</sub> treatments of the 40 natural populations sampled. Collecting sites, numbered under the bars, are the same as in Table 1. A. The 25 population samples from Virginia counties contaminated with aflatoxin; B. The 15 population samples in Virginia counties not contaminated with aflatoxin; C. Combined values for the contaminated (C) and the uncontaminated (U) populations.

Figure 2C illustrates that at each of the concentrations of AFB<sub>1</sub>, overall egg-adult viability was significantly greater for populations from aflatoxin-contaminated areas ( $\bar{x} \pm \text{SEM}$  for 0.5 ppm =  $14.71 \pm 0.66$ , for 1.0 ppm =  $8.64 \pm 0.70$ ) than for populations from uncontaminated areas ( $\bar{x} \pm \text{SEM}$  for 0.5 ppm =  $11.70 \pm 1.14$ , for 1.0 ppm =  $5.71 \pm 1.15$ ; ANOVA contaminated vs uncontaminated for 0.5 ppm:  $F=4.41$ ,  $P<.05$ , and for 1.0 ppm:  $F=5.02$ ,  $P<.05$ ). At 0.5 ppm AFB<sub>1</sub>, fruit fly populations from aflatoxin-contaminated areas had significantly shorter egg-adult development times than those from uncontaminated areas (ANOVA  $F=17.24$ ,  $P<.001$ ). Fly populations from contaminated areas also had significantly greater egg-pupal viability (ANOVA for 0.5 ppm:  $F=52.44$ ,  $P<.001$ , and for 1.0 ppm:  $F=37.17$ ,  $P<.001$ ) and shorter egg-pupal development times (ANOVA for 0.5 ppm:  $F=21.27$ ,  $P<.001$ , and for 1.0 ppm:  $F=22.02$ ,  $P<.001$ ) than fly populations from uncontaminated areas when tested at 0.5 and 1.0 ppm AFB<sub>1</sub>. No significant differences were observed in the body lengths of males and females from the two areas.

#### Chromosome substitution analysis

Data for egg-adult viability among the substituted strains and the controls are given in Table 2 and illustrated in Figure 1. Analysis of variance showed that other than the control strains RX23 and SX23, strains RX3-S2, R3-SX2, R2-SX3 and R23-SX had significantly greater egg-adult viabilities at 0.5 ppm AFB<sub>1</sub> than the remaining two strains tested. At 1.0 ppm AFB<sub>1</sub>, strains R3-SX2, R2-SX3 and RX3-S2 had the greatest egg-adult viabilities. The most sensitive strains at 0.5 and 1.0 ppm AFB<sub>1</sub> were RX-S23 and RX2-S3. R23-SX also was among those with the lowest viabilities at 1.0 ppm AFB<sub>1</sub>. The strains ranked in the same order for egg-pupal viabilities as egg-adult viabilities; however, the differences between the strains was not as pronounced. There was no significant difference in egg-pupal and egg-adult development times at 0.5 and 1.0 ppm AFB<sub>1</sub> in regards to resistance/sensitivity and chromosomal variation. The body lengths of adult males and females generally decreased with increasing concentrations of AFB<sub>1</sub>.

#### DISCUSSION

Data presented in this study show that natural populations of Drosophila melanogaster vary significantly in response to dietary aflatoxin B<sub>1</sub> and that resistant populations are found in aflatoxin contaminated areas. Flies from contaminated areas had not only a greater number of surviving adults when exposed to dietary aflatoxin but also had development times that were significantly shorter than flies from uncontaminated areas. This suggests that natural selection may be a factor contributing the levels of resistance of D. melanogaster to the toxic effects of AFB<sub>1</sub>. Substituting chromosomes of the sensitive strain (SX23) and the resistant strain (RX23) shows that autosomal factors provide increased resistance to AFB<sub>1</sub> with chromosome 3 conferring the highest degree of resistance (R3-SX2). The RX chromosome appears to have a deleterious effect on resistance to AFB<sub>1</sub> toxicity since strains RX3-S2 and RX2-S3 had less resistance to AFB<sub>1</sub> than R3-SX2 and R2-SX3. Harmful effects of the RX chromosome may also account for the observation that strain SX23 had greater egg-adult viability at 0.5 ppm AFB<sub>1</sub>, than RX3-S2, RX2-S3, and RX-S23.

Strain RX23 did not indicate the presence of a deleterious X chromosome possibly because the RX23 combination may epistatically mask any ill effect produced by the X; or perhaps a resistant X chromosome can enhance resistance to AFB<sub>1</sub> when in combination with R23 and reduce resis-

Table 2. Effect of larval growth in aflatoxin B<sub>1</sub> supplemented media on the number of adults produced for the various chromosomally substituted strains.

Strain	Number of adults per vial ( $\bar{x} \pm SE$ ) <sup>a</sup>		
	0.0 ppm <sup>b</sup>	0.5 ppm	1.0 ppm
RX-S23	14.10 $\pm$ 1.85	1.89 $\pm$ 1.27	1.00 $\pm$ 0.0
RX2-S3	13.70 $\pm$ 2.54	2.66 $\pm$ 1.22	1.25 $\pm$ 0.50
RX3-S2	14.20 $\pm$ 3.55	6.40 $\pm$ 1.65	4.11 $\pm$ 1.27
R23-SX	18.44 $\pm$ 3.00	10.45 $\pm$ 2.65	2.22 $\pm$ 1.72
R3-SX2	14.00 $\pm$ 0.94	12.30 $\pm$ 3.16	7.90 $\pm$ 2.85
R2-SX3	16.89 $\pm$ 2.71	10.20 $\pm$ 2.14	5.30 $\pm$ 1.95
RX23	17.30 $\pm$ 3.20	15.20 $\pm$ 2.90	12.50 $\pm$ 4.22
SX23	17.10 $\pm$ 2.42	9.90 $\pm$ 2.13	6.50 $\pm$ 3.17

a. Each treatment was replicated 6 times; each vial initially contained 25 eggs.

b. ppm AFB<sub>1</sub> in the culture medium.

tance when present with either R2-S3 or R3-S2, since R23-SX is less resistant than RX23 at 1.0 ppm AFB<sub>1</sub>.

The presence of genes conferring resistance to AFB<sub>1</sub> may cause an overall increase in viability. Under control conditions (0.0 ppm AFB<sub>1</sub>), strains R2-SX3 and R23-SX had significantly greater egg-adult viability than did the other strains in which chromosomes were substituted; also, under the same control conditions, flies from aflatoxin-contaminated areas had significantly greater egg-adult viability than flies from uncontaminated areas.

If selective pressures in the environment lead to an increase in resistance to AFB<sub>1</sub>, the question of how *Drosophila melanogaster* is exposed to the fungus and its toxic metabolites arises. Drought conditions in Virginia during the summer of 1980 contributed to unusually high levels of *A. flavus*/aflatoxin in corn and peanut crops. Many corn samples tested had greater than 400 ppb AFB<sub>1</sub> [Personal communication from T. Eadie, Virginia Department of Agriculture], and *A. flavus* was detected in samples of peanuts from all the major peanut growing counties [Personal communication from S. Webb, Virginia Department of Agriculture and consumer Services, Suffolk, VA]. prolonged contact with these crops is not a primary mode of exposure of *D. melanogaster* to aflatoxin. However, a variety of substrates, including fruits in the diet of the flies, may support growth of the fungus. Decaying fruit and other rotting materials, especially when located near contaminated corn and peanut fields, may become infested with

A. flavus by airborne spores or insect activity providing a likely route of exposure of D. melanogaster to the toxin. Some fruit flies were trapped in corn, peanut and soybean fields indicating that they can directly become infested with A. flavus propagules. Pettit et al. [1973] studies the survival of A. flavus propagules in peanut soils and showed that the incidence of A. flavus remains high in soils from fields on which peanuts are grown continuously and that corn or peanut residues left undisturbed on the soil results in a buildup of A. flavus populations.

D. melanogaster may be exposed to aflatoxin via airborne dust contamination. Downwind dust samples collected when contaminated corn was being transferred by augers from a storage bin into a wagon and back into the storage bin were analyzed by Burg et al. [1980] and found to have an aflatoxin B<sub>1</sub> content range of 12.5 to 204.3 ppb, with an average of 138 ppb. Such dust could settle on surfaces where D. melanogaster rests. Flies tested in this study often were trapped in orchards near a peanut or corn field where harvesting was underway or had been completed.

Although this study offers no direct evidence that any of the aforementioned potential sources of aflatoxin contamination of D. melanogaster actually transmit the fungus, the fact that resistance of fruit flies to this toxin is higher in populations from contaminated areas indirectly indicates that the fungus and its metabolites may become fairly widespread in the environment. Testing the contamination levels of a variety of substrates which may be exposed to natural infestation where and when A. flavus contamination is high seems highly advisable.

#### ACKNOWLEDGEMENTS

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*Callixylon* Wood From The Greenland Gap Group  
(Upper Devonian) of Southwestern Virginia

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**Abstract:** A specimen of permineralized fossil wood belonging to the genus Callixylon is reported from the Greenland Gap Group of Upper Devonian age in southwestern Virginia. Study with the scanning electron microscope provided information resulting in a detailed description of the wood and characteristics useful in generic determination. This occurrence extends the geographic range of the genus and documents the presence of fossil axes preserved in pyrite from the area.

The genus Callixylon is a form genus for anatomically preserved wood having progymnospermous characteristics and is important as a possible indicator of the presence of the progymnosperm Archaeopteris. In the United States the genus has been reported from many Upper Devonian localities (Arnold 1931; Beck, 1962, 1979; Beck et al., 1982; Gillespie et al., 1981). The Devonian localities range through New York, Michigan, Kentucky, Ohio, Oklahoma, and West Virginia and by reason of this distribution it is not really surprising to find Callixylon in southwestern Virginia. Some Mississippian reports of the genus occur as well (Matten, 1972, from Tennessee). The occurrence in Virginia is now documented and the geographic range of the genus is extended. This area represents the southern tip of the eastern arm of the Old Red Continent which lay close to the paleoequator during late Devonian time (Bambach et al., 1981).

#### Materials and Methods:

Three axes preserved by pyrite were found in a sandstone. The locality was discovered and material first collected by Richard K. Bambach at Virginia Polytechnic Institute and State University, 2 km north of locality 11 of Bambach & Kreisa (1973). This new locality is about 5 km north of Blacksburg, VA along highway 460 on the south slope of Brush Mountain. The Upper Devonian beds in this region have traditionally been treated as the Chemung Formation (Englund et al., 1979). However, Dennison (1979) has proposed new nomenclature and according to his classification the beds discussed here lie within the Foreknobs Formation of the Greenland Gap Group.

The axes were poorly preserved and they fractured very easily. Preparation was difficult because of this character. The axes tended to crumble into many pieces if they were not first embedded in Ward's Bioplastic before cutting thin sections on a diamond saw; subsequent coating of each section with epoxy glue and grinding proved the most successful treatment for light microscopy. Axis number 3 (USNM 326722) was prepared in this manner resulting in twenty transverse sections and three longitudinal sections. A portion of axis number 2 (USNM 326721) was also embedded and sectioned resulting in six longitudinal sections. However, the sections still could not be ground per-

fectly flat in all areas without some fracturing of the material. The remaining portion of axis number 2 was split into ten sections for study by light microscopy and by scanning electron microscopy without carbon or metallic coatings. Axis number 1 (USNM 326720) was prepared for scanning electron microscopy by a method described by Grierson (1974): a technique that avoids problems associated with thin sectioning. Some sections were split; some were gold coated and others were left uncoated. The best results were obtained from those split sections that were oxidized in Schulze's solution for 30 to 60 seconds, washed with water, then air dried. The material was mounted on 12 mm round cover glasses with a thin layer of white glue and dried. The cover slips were mounted on stubs with Electrodag 191 SEM glue, coated with carbon and then gold. This double coating eliminated almost all of the charging problems. The sections were observed under one of three microscopes at the National Museum of Natural History, Smithsonian Institution, Washington, D.C.: a Cambridge S4-10, A Cambridge Mark II A, and a Coates and Welter Field Emission Microscope. Specimens are now deposited at the Museum of Natural History, Paleobotany Collection: USNM 326720 (axis 1), 326721 (axis 2), and 326722 (axis 3). All photographs figured in this paper are from USNM 326720.

#### Description:

The fossil material is all secondary xylem with no obvious growth layers as can be seen in the transverse section (fig. 1). The wood is composed of tracheids, 40-50  $\mu\text{m}$  in diameter, and uniseriate or biseriate rays (fig. 1 & 2). The biseriate rays may be uniform in width for their entire length except at the ends (fig. 2) or biseriate at the mid-portion only. All rays range from 6 to 20 cells high and are elliptical in tangential section.

The ray cells, which are mostly all tracheids, are rectangular (25-40  $\mu\text{m}$  vertically). They are tightly grouped and only an occasional intercellular space was observed (fig. 2 & 3). A variety of pits may occur on the ray cells from bordered to almost simple (fig. 5 & 6). Cross-field pitting between the tracheids and ray cells may be the most variable (fig. 4 & 5). Pits between the ray cells have the least amount of border present.

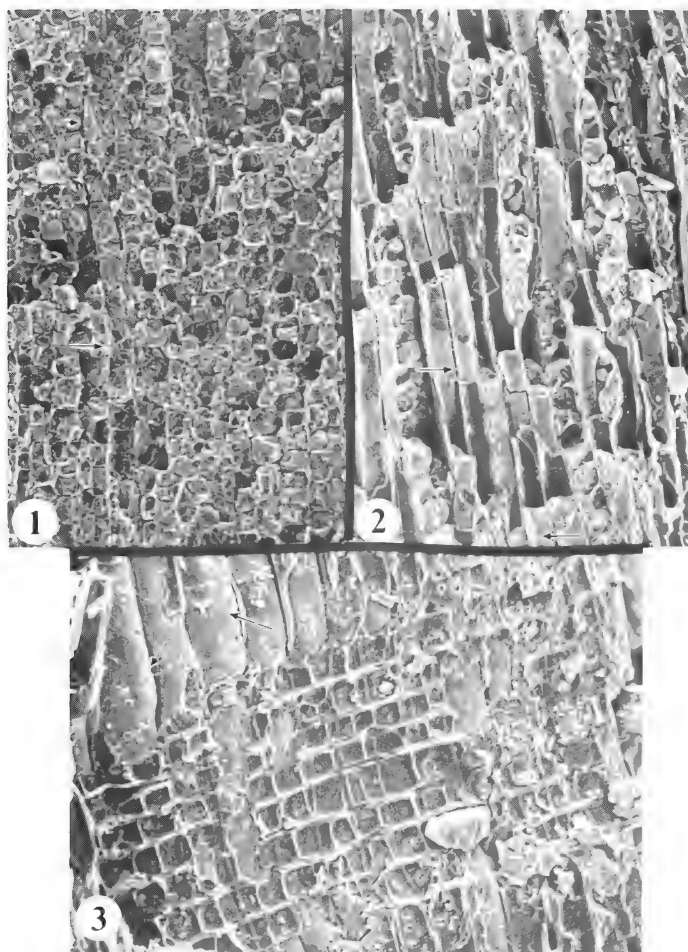
The tracheids have groups of 2 - 10 bordered pits which are arranged in 1 - 2 (rarely 3) rows on the radial walls (fig. 4 & 5). The pits are circular to slightly oval, 4 - 8  $\mu\text{m}$  in diameter. The apertures appear to be usually aligned; however, debris and pyrite often obscured observation of the orientation. Occasionally there is a small pit on the tangential wall of a tracheid, but then only near the side that curves toward the radial wall (fig. 2).

The pits in the walls of the tracheids are always bordered to some extent. The borders may be very distinct (fig. 7), or they may be shared by coalescence between adjoining pits (fig. 8). Along the length of a tracheid the pits are always in groups separated by areas of the wall wholly free of pits. The pit groups in adjoining tracheids are aligned radially in uniform rows which is characteristic for the genus Callixylon (fig. 4 & 5).

Even though this material was quite fractured and crumbled easily, as can be seen by the extensive debris in the photographs, there are several characteristics worth noting particularly. The pits are variable in size and shape on the tracheids. While mainly oval, some are round with extensive borders. Others have a much narrower border surrounding them. The extensive broader borders sometime coalesce resulting in shared pit cavities within the pit groups. Unfortunately no pit membranes could be positively identified in the material from Virginia. Often these shared borders occur in areas of cross-field pitting (fig. 5) but the shared borders also occur between tracheids. Thus no definite correlation of position could be made.

#### Discussion:

The characteristics of these fossil wood fragments conform with those of the genus Callixylon, with particular reference to the consistent grouping of



**Fig. 1.**

Transverse section of wood showing tracheids and vascular rays (arrows). The factured nature of the material can also be seen with debris from the coating procedure. Photographed at 100 ×

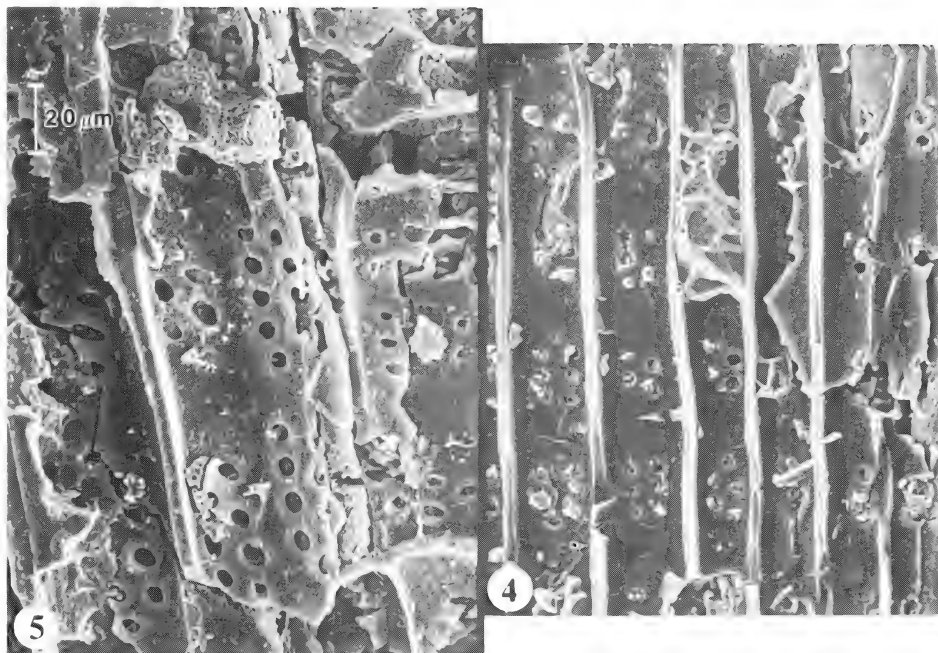
**Fig. 2.**

Tangential section of wood. Note uniseriate and biseriate rays, pitting of tracheids with occasional pit on the tangential wall (arrow). Photographed at 120 ×

**Fig. 3.**

Radial section of wood showing ray and grouped pitting of all cells (arrows). Photographed at 200 ×



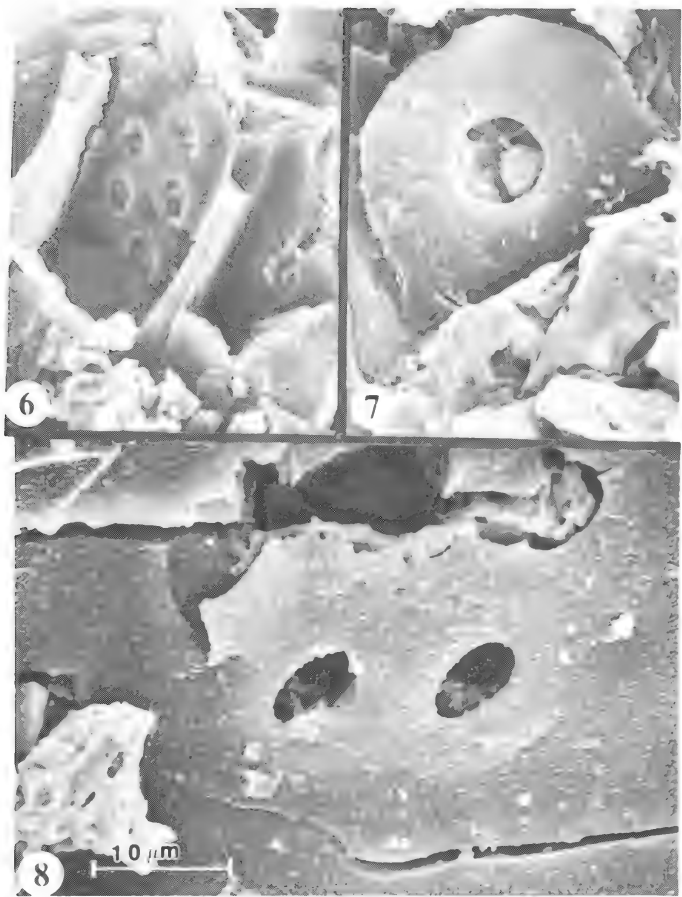


**Fig. 4.**

Radial view of the interior of tracheids enlarged to show grouped pitting and narrow borders of pits. Photographed at 360 ×

**Fig. 5.**

Radial view of tracheids with ray immediately below them to show cross field pitting. Shape of pits varies from circular to oval. Borders within some groups raised (center of photo). Photographed at 600 ×



**Fig. 6.**  
Ray tracheid showing pits with narrow borders. Photographed at 1000 ×

**Fig. 7.**  
Circular bordered pit of tracheid with wide border. Photographed at 3000 ×

**Fig. 8.**  
Bordered pits of tracheid with coalesced borders. Photographed at 2600 ×

bordered pits in the secondary walls of the tracheids. The common occurrence of the genus as isolated axes in Upper Devonian sediments also lends some additional credence to the positive identification of the fragments described herein. All three axes seem to represent the same taxon.

While the genus Callixylon is better identified when primary growth is also preserved the generic name has been unhesitatingly applied to fragments of secondary wood (Beck, 1962; Matten, 1972). Other form genera, such as Desmoporoxylon are in need of better descriptive detail before comparison can be made with the specimens described here.

The species included in Callixylon are difficult to distinguish because of considerable variability and resultant overlapping of characters. Arnold (1931) in cautioning against establishing new species of Callixylon noted that variations in tracheid diameter, the number of pits per grouping, the contents of ray cells, and presence or absence of growth rings are not reliable species characters. Beck et al. (1982) also describe the difficulty of identifying Callixylon to species. Thus the specimens described here are simply reported as Callixylon sp. As more of the Callixylon material from the locality cited here is studied with the scanning electron microscope better specific assignments may be made.

The technique of preparation for the scanning electron microscope proved to be advantageous. Coating of the specimens with carbon followed by gold practically eliminated problems of charging even though more debris developed from and around the specimens as a result of the longer period under vacuum. As a result of the disintegration of the specimens more cell detail could be examined than when no coating at all was applied or only a coating of gold was used.

This material described and illustrated here is significant because of the extension of the geographic range of Callixylon, the documentation of the occurrence of pyritized plant material in the Upper Devonian of southwestern Virginia, and the additional study of specimens of Callixylon with the scanning electron microscope.

#### Acknowledgements:

The author thanks Dr. Francis M. Hueber for the use of his laboratory facilities at the National Museum of Natural History and Mr. Jan Endlich for aid in preparing the figures.

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## Prevalence and Distribution of Lungworms of Swine Raised in Small Farm Units of Southside Virginia

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### ABSTRACT

The prevalence of helminths was determined from swine fecal materials collected from 136 small farm units of Southside Virginia. The survey was conducted during the summers of 1980 and 1981. Out of the twenty-seven counties surveyed, fecal samples from seven revealed the presence of lungworm (*Metastrongylus* spp.) infection in pigs. The highest percentage prevalence of lungworm of swine was recorded as 35.0% of the twenty samples analyzed for Charles City, followed by 16.6% of the twelve samples examined from Mecklenburg County and 10.8% of the thirty-seven fecal samples analyzed from Powhatan County. The overall lungworm egg counts as revealed by fecal analysis from all the twenty-seven counties were low (3%) and sporadic.

The observation of such low incidence of swine lung-worm infection is not uncommon as other researchers from the Southern states, especially from the mid-atlantic region, reported similar findings. The prevalence of helminths appeared to be related to the overall quality of management.

### INTRODUCTION

Lungworms (*Metastrongylus* spp.) are most frequently present among hogs raised in open hog lots (Alicata, 1964). Most metastrongyles are called 'lungworms' and they usually inhabit the respiratory or circulatory systems of carnivores, ungulates, rodents and primates throughout the world.

Numerous reports indicate the presence of lungworm infection in the United States. When the species have been identified, both *Mestaststrongylus elongatus* and *M. Pudendotectus* have usually been found together in mixed infestations, the former species usually being seen more frequently and in greater numbers than the latter, although Ledet and Greve (1966) found both species present in almost equal numbers in swine. Ewing and Todd (1961) also found *M. salmi* present in mixed infestations, but only one percent of the infected pigs carried this species (Rose, 1973).

Light to moderate infections cause no marked clinical symptoms in pigs, but heavy infections can cause pneumonia and other respiratory disease and may cause death as mentioned by Sullivan and Shaw (1953).

Several workers have described the pathology of both natural and experimental swine lungworm infections in varying degrees of detail (Hollow, 1966; Tiunov, 1966; and Rose, 1973).

The value of swine marketed in North Carolina alone has increased from 96 million dollars in 1965 to 247 million dollars in 1974 and it was projected that by the eighties, 10 million heads of swine will be produced in the coastal plains regions of Virginia, North Carolina and South Carolina. According to the USDA (1965), swine lungworms cause an annual loss of \$3,584,000 in the U.S.A., of which \$171,000 is due to death and the remainder to illness. These facts coupled with (1) lack of data of these worms in definitive hosts from small farm units in Southside Virginia and (2) the changes in this region's population, trade and socio-economy indicated a need for up to date information on this important parasite of pigs.

#### MATERIALS AND METHODS

Trips were made to small farm units in twenty-seven counties and three feeder pig sales in Southside Virginia. A total of 136 farms were visited during the summer months of 1980 and 1981. Freshly discharged pig feces from the identified animals were used for analysis.

Disposable boots and gloves were used to prevent the transfer of parasite ova from one farm to another. Fecal samples were placed in polyethylene specimen bags and refrigerated at 7°C for not more than 3 days prior to analysis.

The method found to be reliable and most satisfactory for analysis of helminth ova is Sheater's Sugar Flotation Technique. The solution has a specific gravity of 1.2 and is most useful when looking for nematode eggs (Palmieri and Anderson, 1979).

A concentrated solution was made by dissolving 390 g of sugar in 250 ml of hot (90°C) water. Once cooled, 4.6 g of phenol was added to the solution to deter mold growth. The concentrated stock solution was thoroughly mixed 1:1 with tap water at room temperature just before use.

Two g of fecal sample was placed in large crucible with 20 ml of the 1:1 sugar/flotation solution and thoroughly mixed until suspended. The mixture was poured through cheesecloth and the remaining debris was discarded. The suspension was centrifuged at 200g for 5 minutes in a clinical centrifuge.

The centrifuged material was allowed to stand for 5 minutes before analysis. A special glass rod with a flat head was dipped into a centrifuge tube until it just touched the upper layer of the mixture. The head of the glass rod containing the specimen was then touched to a drop of water placed in a 3x1 inch glass slide and covered carefully with a coverslip to avoid trapping of air bubbles. Finally, the parasite ova were identified and measured under the microscope equipped with a micrometer. The identification of lungworm ova was based on the description outlined by Morgan and Hawkins (1960).

#### RESULTS AND DISCUSSION

Three percent of the total 568 swine fecal samples collected from pigs of all ages from small farm units of Southside Virginia were positive for lungworm infection. This survey showed that the incidence of lungworm infection was 35% of the twenty samples examined from Charles City County, followed by 17% of the eleven samples examined from Mecklenburg County and 11% of the thirty-seven samples analyzed from Powhatan County. Other counties with 3 to 10 percent prevalence of lungworm were Appomattox, Dinwiddie, Sussex and Greenville counties (Table 1).

Sixty five swine fecal samples also collected from three other feeder pig sales at Farmville, Southampton and Tappahanock of Southside Virginia were found to be negative for lungworm infection.

Fecal egg counts were determined. The lungworm egg counts were low and sporadic. This was not considered unusual, as there is a scarcity of

scientific reports linking metastrongyle egg counts to clinical disease (Dunne, 1959).

The incidence of lungworm infection as recorded by different workers varies considerably. Andrews and Connelly (1945) in Georgia, Batte and Moncol (1966) in North Carolina, and Riddle and Forrester (1972) in South Carolina found a low incidence of lungworm infection (Table 2). Kelly and Sen (1959) in Nebraska and Nevenic and Sibalic (1953) in Yugoslavia also found a low incidence of swine lungworm infection.

Swine lungworms are pathogenic both in their own right and because they may transmit or exacerbate certain diseases. Loss of condition and retarded growth are common results of infection, and young pigs may be killed by heavy infections (Levine, 1980). The United States Department of Agriculture has estimated the annual loss due to harmful effects caused by internal parasites of swine to be more than 275 million dollars (Stewart and Southwell, 1960). A large portion of this loss occurs in the southern states. In North Carolina, for example, internal parasites reduced the value of swine by at least one dollar for each pig marketed (Batte and Moncol, 1966). The control of swine parasites, therefore, is a major problem, particularly since intensification and expansion of the swine industry has not been accompanied by the reduction of worm populations (Batte et al., 1965).

The pigs raised on small farm units of Southside Virginia, in this survey, were subjected to the most primitive forms of swine management. Animals were kept in dirt pens that were at best irregularly cleaned and remained shaded and moist throughout the year. However, a few farms had access to open pasture. Most of the farmers were primarily of the lower socioeconomic category and were part-time swine producers. They placed little or no emphasis on housing, nutrition or health of their pigs and were unaware of modern swine management practices.

Swine lungworms (*Metastrongylus* spp.) were detected in Charles City, Mecklenburg, Powhatan, Appomattox, Dinwiddie, Sussex and Greenville counties of the Southside Virginia. The majority of farmers in these counties kept their animals in open hoglots where the intermediate (earthworm) hosts were present in great numbers. Since the earthworms are the

Table 1. Percentage prevalence of *Metastrongylus* spp. of swine in Southside Virginia as determined by fecal analysis during 1980-81.

County	Locality	No. Infected/ No. Examined	Percentage Infected
Charles City County	Southside Virginia	7/20	35.0
Mecklenburg County	"	2/12	16.6
Powhatan County	"	4/37	10.8
Appomattox County	"	2/20	10.0
Dinwiddie County	"	2/24	8.3
Sussex County	"	1/22	4.5
Greenville County	"	1/33	3.0
Remaining 20 Counties	"	0/400	0.0
Total		19/568	3.3

Table 2. Comparison of percentage prevalence of *Metastrongylus* spp. of swine in Georgia, North Carolina and South Carolina with the present study (Southside Virginia)

Investigators	Percentage Prevalence	Area (years of analysis)
Andrews and Connelly 1945	14	Georgia (1943-44)
Batte and Moncol 1966	0	North Carolina (1965-66)
Riddle and Forrester 1972	5	South Carolina (1968-69)
Sen et al., 1983	3	Southside Virginia (1980-81)

intermediate hosts of swine lungworms, measures which prevent pigs from rooting in the ground and eating earthworms will prevent lungworm infections. If possible, hogs could be kept on concrete and their feces should not be spread on pastures where pigs will later run (This ideal situation prevailed in 20 counties where lungworm infections were not prevalent).

Good sanitation and adequate nutrition will go a long way to protect pigs, raised in Southside Virginia, from parasites. No drug will remove all the internal parasites (although specific chemotherapeutic drugs are available for swine lungworm infection), and certainly, the damage done by the migrating worms cannot be cured (Stewart and Hale, 1978). A good system of management will incorporate practices aimed at the prevention of infection and will not use treatment as the sole method of controlling parasites.

#### ACKNOWLEDGEMENTS

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## **A Computer Data Acquisition and Analysis Program for the Laboratory**

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### **ABSTRACT**

An available software system for laboratory data collection is described having broad application in computer assisted experimentation. Program features are described for data analysis, and hardware considerations are outlined with recommendations for program utilization with or without program code modification. The intent is to acquaint potential experimenters with the fundamental considerations of such a project by example.

### **1. The Expansion of Computer Utility**

Electronic computational devices continue to have increasing influence on daily life. Commonly these devices appear in specialized products such as calculators, toys, clocks, stereo equipment and televisions. In these cases the computational function is fixed or the user has little control over modifying the dedicated nature of the computer. In a more limited extent, the truly all purpose, totally programmable computer is also finding wider acceptance until ultimately domestic computers may be commonplace.

The computer has become an indispensable tool in many aspects of data collection and analysis. The increased accuracy and productivity afforded is no longer a matter of convenience, but of necessity in conducting ever more complex experimental procedures. The alleviation of complexity in performing the experiment by introduction of a computer actually only shifts the complexity into the design stages. But, once the design is finalized, an experiment may be conducted with a high degree of precision and repeatability.

In the design one must consider the interfacing of computer to experiment and establishment of a means for manual and automataic control. Decisions must be made as to which functions will be provided by hardware or by software

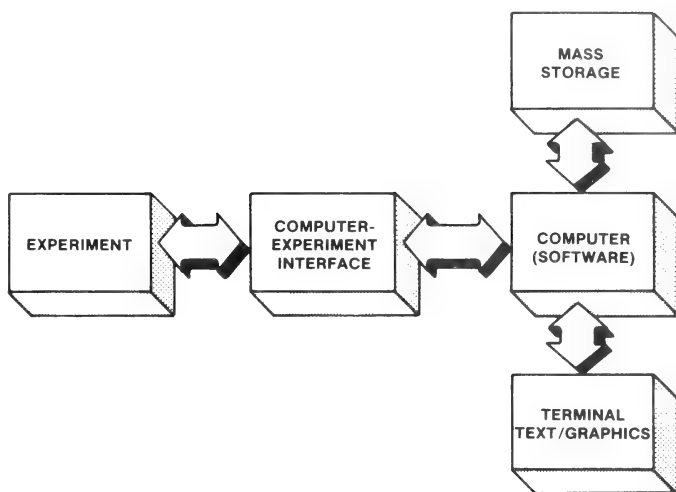


Fig. 1.

Components of typical computer assisted experimentation.

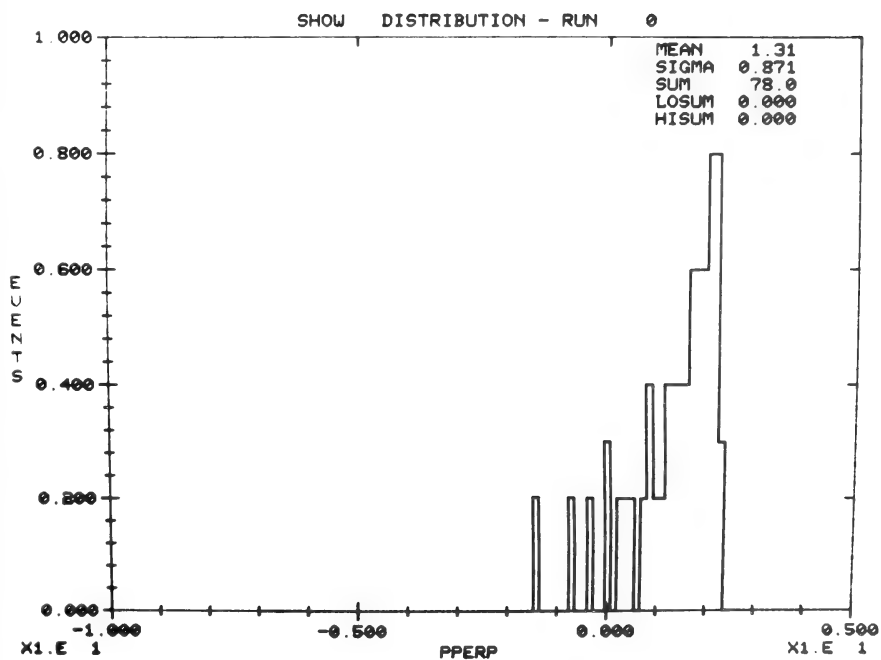


Fig. 2.

The graph called 'show' exemplifies the MULTI histogram support feature for data analysis.

(programs) and extensive testing of both together and separately must be done. One will inevitably find that while hardware is diverse in selection and reliable in operation, implementation of software is primarily a user's responsibility. Software design often becomes the most expensive phase of the project and, if not implemented properly, can easily hinder progress.

This paper has been prepared to acquaint a potential experimenter with the overall problems and advantages of using computers and to describe a program called MULTI for use directly or as a model in software preparation.

## 2. Applicability

The Fermilab National Accelerator research facility at Batavia, Illinois has created a computer program named MULTI functioning as a data acquisition and analysis tool for laboratory experimentation. MULTI's intended application is within particle physics, however the program is of sufficient generality to recommend itself to other unrelated applications.

We present here a description of the general role a computer may fill in experimental situations, the functions MULTI provides and a suggestion for using MULTI in the general laboratory situation.

### a. Experiment Hardware

The fundamental aspects of a computer assisted experiment are summarized in figure 1. Three main components comprise the minimum design. One component, the experiment itself, produces data to be communicated into the computer, the second component. In more sophisticated systems the flow of data can be reversed from computer to experiment. This provides for automatic control through feedback paths. A third component, the computer to experiment interface, is responsible for this uni- or bi-directional data path. It provides for translation of data and control signals into analog or digital forms appropriate to the hardware.

The computer alone is made up of several modular parts to function as the human to machine interface. A terminal upon which an operator enters commands and receives responses is necessary for interactive control. This same terminal or a separate device should be capable of displaying graphical data. Some form of storage such as a magnetic tape drive is a necessity for recording voluminous data. Typically, a spinning magnetic disk known as a direct access storage device is used to store various programs and small data files.

### b. Experiment Software

An integral part of the system is the program running it. An insufficiently designed software system can destroy the performance of the best hardware. Programs can be cryptic,

inconvenient and unreliable. Too often programs are thrown together for immediate results and the cost of such practice later becomes evident. Software design is best when it assumes simplicity, has a logical organization, and assumes an analytic role during execution. The analytic function is exemplified by such practices as coding into programs a dialogue to explain commands, verify data, and confirm user intentions at critical experiment stages. This feature can be helpful in preventing potentially destructive command sequences from being inadvertently entered.

The complementary function that software fills in experimentation might include the following attributes:

- can incoming data be easily manipulated through keyboard commands?
- can data be automatically monitored and appropriate action taken?
- can data be displayed graphically as they occur?
- are the data recorded and catalogued properly with easy access?
- is the system expandable on the user and programmer levels?
- is the documentation describing the system adequate for novice users?

The above mentioned qualities are general enough to apply in most computer assisted experiments. Indeed they are the major aspects of Fermilab's MULTI software which is specifically discussed below.

### 3. MULTI Operation

Human to machine communication in interactive systems is commonly accomplished through commands entered on a keyboard and responses displayed on a television screen device. These commands usually take the form of a keyword and parameter list where the keyword invokes a basic function and parameters determine specific actions within it. A sample of the communication scheme taken from MULTI will illustrate both the programming technique and a facility of MULTI.

#### a. A Sample MULTI Session

MULTI is useful over the full range of an experiment's duration from design, to control, to indepth analysis. If experiment hardware is not yet available, the software development may proceed with a simulation method of data collection provided by MULTI. When data have been recorded it is possible to replay the collected data and analyse them extensively. The following command/response sequence illustrates several MULTI capabilities. It is responsible

for producing the graph of figure 2 which was taken photographically from a Tektronix 4010 vector drawing terminal. The > sign is a prompting character indicating MULTI will accept operator commands.

>SET DATA=MT

The user indicates that an experiment playback from magnetic tape is to occur.

>HIST DA6,SHOW,1024,0,1023

The keyword HIST indicates that a histogram is to be constructed from entering data. The following parameters respectively establish where data are to be found in memory (location DA6), a histogram name for operator reference (SHOW), bin count (1024), originating and terminating bin values (0,1023).

>DISPLAY SHOW

The previously defined histogram is displayed on a graphics device.

>CONTINUE

This initiates reading of a tape. As data enter MULTI, the histogram is updated internally and because it is under active display these updates are immediately conveyed to the graphics device. A number of histograms may be defined simultaneously and called up for individual display during data acquisition.

#### b. The Practical MULTI

Consideration must now be given to the practical aspects of implementing MULTI on real hardware. MULTI's requirements vary depending on the desired function of MULTI itself, however a minimum system would include a Digital Equipment Corporation's LSI-11 computer (Digital Equipment Corporation, Maynard, Mass., 01754 with 28K words of memory and enough external disk storage (about two megabytes) to generate MULTI. The user generates MULTI by selecting various subroutines then compiles and links them into a runnable program. A graphics device, printer and magnetic tape unit are highly desirable but not necessary to run limited versions of MULTI.

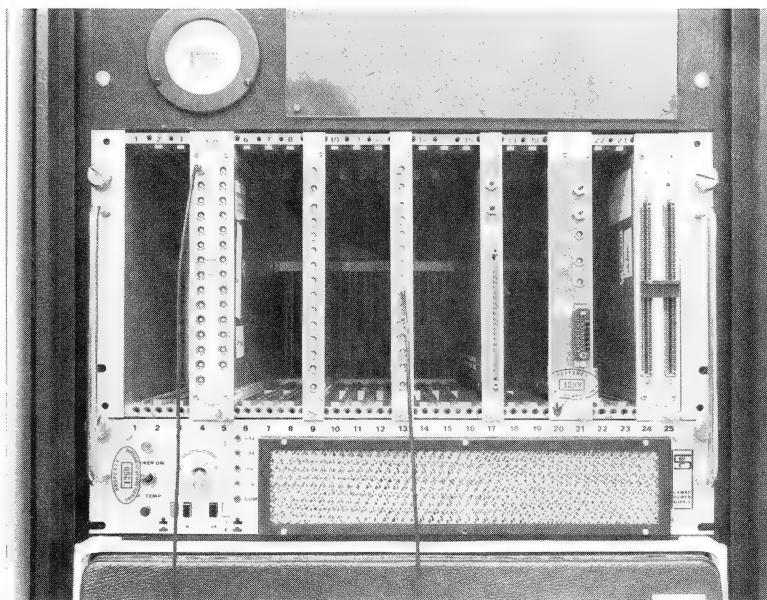


Fig. 3.

The CAMAC crate functions as an interface of experiment to computer. It is a device on the common external device control channel as are other hardware components such as disk and tape drives.

### 1.0 MULTI

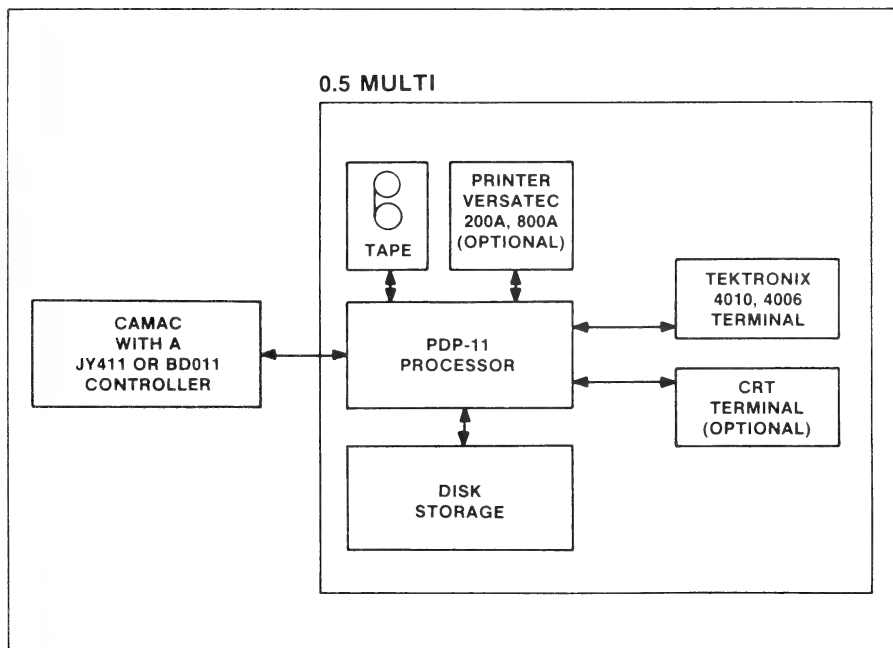


Fig. 4.

The relative functional differences between MULTI versions 1.0 and 0.5 are only those of data acquisition capability. User versions of MULTI are possible by modifying the 0.5 system.

### c. Different MULTIs

The user puts together a MULTI configuration according to the hardware available. The most capable MULTI is also the most specific in hardware requirements. The user may feel compelled to attempt code modification for personalized versions of MULTI utilizing hardware unique to the installation. This would be done by selecting the standardized version of MULTI most appropriate to the application and then building upon it.

There exist two documented versions of MULTI called the full and the half systems designated 1.0 and 0.5 respectively. A full system provides the capabilities as described above for general laboratory setups using very specific hardware. Since the partial system, as a subset of the full one, provides only the analysis function, hardware requirements are less stringent. We first consider intricacies of MULTI 1.0 in the laboratory environment.

### d. The CAMAC Crate

To fulfill the function of the computer to experiment interface, the level 1.0 MULTI is written utilizing a CAMAC crate as seen in figure 3. CAMAC (for Computer Automated Measurement and Control) is a standardized interface of computer to a wide range of modular plug-in devices useful in experiments to perform such functions as analog to digital conversion, digital to analog conversion, pulsing, timing, counting, stepper motor control and interrupts. It was developed and is widely used by high energy physicists.

The software necessary to utilize the device is available within MULTI 1.0 in two forms. First, there is a convenient sub-language supported by MULTI in which the user programs CAMAC module servicing code. When an event of interest occurs, the computer is directed to the CAMAC code which typically would read out data and reset the experiment in preparation for another event. Secondly, a well documented set of subroutines exist for controlling CAMAC for the FORTRAN level programmer independent of MULTI. It must be indicated that MULTI 1.0 requires a special crate control module known as the JY411(Jorway Corp., 27 Bond St., Westbury, N.Y., 11540).

Obviously the full system is quite hardware dependent in the computer to experiment interface aspect. Unless you have access to the proper CAMAC hardware, MULTI 1.0 is of no use. Additionally, MULTI 1.0 expects to find special FERMILAB designed hardware on line. Although a laboratory may possess the specified CAMAC equipment, it is still necessary to disable that part of MULTI making reference to unique Fermilab hardware.

Figure 4 shows the relationship of MULTI 0.5 to 1.0 in terms of specific hardware requirements. It is seen that the basic difference is simply that of data gathering ability. This makes MULTI 0.5 a simpler analysis only system. It also suggests that MULTI 0.5 is the best candidate for adaptation to particular laboratory needs.



#### e. MULTI 0.5 with Magnetic Tape

The simplest implementation of MULTI would be to use it in unmodified form. Supposing you have already developed data acquisition and recording programs, it would be a relatively easy task to take the recorded data and reformat them into a MULTI style tape. This would amount to simulating the acquisition of data as if MULTI had originally collected and recorded them. The resulting data are then available to a 0.5 MULTI for full analytical study on playback. The structure of such tapes is fully documented in Fermilab publications accompanying MULTI. A programmer familiar with writing for tape devices should be able to produce a successful reformatting program. If such off-line analysis is acceptable, this is the route to follow.

#### f. MULTI 0.5 with an Experimental Interface

If it is desired to have MULTI's analytic capabilities running in parallel with the experiment, a slightly more complex procedure of code modification is necessary. The basic strategy we followed was to exploit the tape reading interface of MULTI in the playback (tape reading) mode. The tape record, as explained in the documentation, is simply a string of binary values grouped into computer words and preceded by a few values of a descriptive nature as to how to use these data. Certainly, a real time sequence of experimental data could be made to look like a magnetic tape record. This would be accomplished by buffering the incoming data into storage and adding onto the front of them the tape record leader information. When a record is complete MULTI can be signaled that data are available. The task to be confronted, then, is grafting into MULTI one's own acquisition code and presenting the accumulated data to MULTI in the form of a simulated tape record. Specifically, the tape read instruction of MULTI code is replaced with code to transfer the collected data to a specific buffer area of memory for MULTI processing.

#### 4. The Structure of MULTI Software

The logical structure of MULTI may be likened to walking a circular hallway lined with doors. As one walks the floor he tries each door. If the door opens he enters to investigate and later returns, closing the door behind him. A locked door is ignored and his walk continues. Each door represents a condition of the system such as a command entered, or a tape record available. The door lock is a flag variable tested by the program whose flow is altered according to the test. A door unlocked is a flag variable set and attention is provided accordingly. This design persuades and suggests to a programmer that, in the adaptation of MULTI to a unique setting, he investigate the methods of data transfer through a convenient channel such as in the tape reading part of MULTI.

MULTI 1.0 is an interrupt drive program. An interrupt is a non-scheduled, random occurrence of some event external to the computer which demands immediate attention from a special segment of the software. When an interrupt occurs

this special code is called up to perform a task as specified by the programmer. In the hallway analogy an interrupt occurs when a door pops open and the walker rushes to enter, ignoring all others. When through, he resumes the walk at the point of interruption.

The acquisition code to be grafted onto MULTI 0.5 can also be interrupt driven. It is in this interrupt code that the simulated tape record is constructed from experimental data and a flag variable is set (a door is unlocked) to initiate an artificial tape read. Alternatively, if the computer to experiment interface is not interrupt driven, a device polling strategy of programming style could be accommodated. In the walker analogy this amounts to adding another door. The programming style adopted depends on what kind of computer to experiment interface is available. The important aspect of the problem is to study the original tape reading MULTI code and devise a method for substituting real time data for tape records.

## 5. Extensions to MULTI

In our own versions we have made numerous extensions to MULTI's capabilities in keeping with our own hardware configuration. Certain areas of memory have been added or extended to make esoteric data accessible through special keyboard commands. We have MULTIs to work with three kinds of CAMAC crate configurations on three different DEC computers. We have added to MULTI a means of producing selected color graphics on a Ramtek 6000A terminal so that up to 8 histograms may be viewed simultaneously or 4 individually as they are updated. This extended MULTI is implemented on a PDP 11/34 with two model RLO1 disk drives using a JY411 controller in a CAMAC crate. Currently the system is used at our experimental site of the Indiana University Cyclotron Facility at Bloomington, Indiana.

## Acknowledgements

We thank T. Lagerlund and L. Taff for their assistance in adaptation of MULTI to our specific requirements.

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## Distribution of *Pinus virginiana* and *Pinus taeda* in the Peninsula of Virginia

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### Abstract

Virginia (*Pinus virginiana*) and loblolly (*P. taeda*) pines are both abundant between the James and York Rivers in Virginia. Studies by R. Monette and S. Ware found loblolly pine to be overwhelmingly dominant in old field succession, with Virginia pine absent or rare even when seed trees of that species were nearby. In our survey we found the same results, and found Virginia pine to be abundant in areas that had been heavily (selectively) timbered (perhaps by cutting out an earlier generation of pine), had been clearcut but not further managed, or had been bulldozed off so that the red topsoil was exposed (sloping road cuts, for instance). Loblolly pine ranged from almost as abundant (usually) to absent (rarely) in these same sites. Despite the clear association with past land use, neither pH, Ca, Mg, K, P soil textures or growing season moisture (measured at 2-wk intervals with Bouyoucos moisture meter) correlated with abundance of the two species.

### Introduction

Virginia pine (*Pinus virginiana*) and loblolly pine (*Pinus taeda*) are both abundant trees in the forests of the central Coastal Plain of Virginia. However, Monette & Ware (1983) found in a study of old field succession in the area that the early forest stage was overwhelmingly dominated by loblolly pine, with Virginia pine absent or insignificant. In a survey of over 40 pine stands, we likewise found that old field pine stands had very little Virginia or shortleaf (*P. echinata*) pine, even when older seed trees of these species were nearby. On the other hand, stands in which Virginia pine attained dominance or co-dominance with loblolly pine were either bulldozed road cuts with the red lateritic subsoil exposed, or more often, cut-over areas with varying degrees of previous timbering. Areas which had been selectively cut (for a previous generation of pine) had more relict hardwoods mixed in with the pines than did areas that had been clearcut, but the ratio of the two major species of pine did not seem to be affected by the degree of previous timbering.

McQuilkin (1940) has described the importance of seed source in establishment of pine stands, rating this factor higher than effects of normal variations in site, soil type and plant cover. However, if the

Table I. Species Composition (density %) of seedling stands and probable seed source stands.

	Seedling Stand	Source Stand
<u>Site 1</u>		
<u>P. taeda</u>	15.5	11.1
<u>P. virginiana</u>	84.5	88.9
<u>Site 2</u>		
<u>P. taeda</u>	19.5	8.3
<u>P. virginiana</u>	69.6	75.0
<u>P. echinata</u>	11.0	16.7

assumption is made that adequate seed supply of both species was available at the time the fields were abandoned or the woods cut, some other answer must be sought to explain why Virginia pine is important only on cut-over areas, usually in co-dominance with loblolly pine; and is unimportant in loblolly-dominated abandoned fields. This study was undertaken to examine several factors that might be involved in this differential distribution of the two pines.

### Methods

This study was made in the area of Williamsburg, Virginia beginning in May 1976. The number of pine stands available for study was limited by local farming or construction activities and the resultant destruction of pine woods; in all, eight stands were selected for their lack of recent (25-30 yrs) disturbance. Stands 1 and 2 are separated from each other by a small hardwood valley; stands 3 and 4 are located on opposite sides of a two-lane roadway and are sufficiently different from each other to be considered separate stands on the basis of species composition. None of the other stands were near each other. All stands were approximately equal in size (2-3 ha) and age (25-30 yr) based on the larger pine trees. Sampling was done with a Spiegel Relaskop (Bitterlich method) and circular quadrats or by the point-centered quarter method. Four of the stands obviously originated on abandoned fields, as traces of crop rows were still evident. The remaining four stands had come in on cut-over areas, indicated by numerous rotted stumps. Stands 3, 4, 7, and 8 were judged to be old field while stands 1, 2, 5, and 6 were cut-over in origin. In addition to these 8 stands two 10-yr old pine stands were studied in an attempt to determine whether seed source controlled species composition in non-old field sites. Each of these stands was long (50 m and 70 m) and narrow ( $\approx$  5m) and located on fairly steep road banks which had originally been bulldozed down to the red lateritic subsoil. Each community bordered a mixed species cut-over woods (larger pines 50+ yrs). In each strip community all pine seedlings were tallied according to species. All cone-bearing pines in the adjoining forest were tallied as probable seed sources if their crown extended out over part of the young pine stand or if their trunk was within 5 m of the edge of the young pine stand.

In the 8 sampled stands, analysis was made of several edaphic factors which could be responsible for favoring the occurrence of either species on

a site. Soil moisture as recorded at two-week intervals beginning in May 1976 and continuing through early November 1976, using a Bouyoucos moisture meter and gypsum blocks buried at 15 cm depths at scattered locations within a stand (but always within 0.5 m of a loblolly pine in the loblolly stands and within 0.5 of a Virginia pine in 'mixed' stands). Several soil samples were taken at each site. Litter and duff were removed and a cylindrical sample was taken to a depth 15 cm. All samples from a stand were blended and divided into two portions. Soil texture analysis was performed on one portion according to the method described by Bowers (1976). Results were recorded in percent values of sand, silt, and clay. The other portion was sent to the USDA Cooperative Extension Service Lab at Virginia Polytechnic Institute and State University for analysis for calcium (CaO), magnesium (MgO), phosphate ( $P_2O_5$ ), and potassium ( $K_2O$ ) and pH. For mineral analysis, samples were taken two different times and the results averaged.

### Results

Seedling--Seed Source Study: It can be seen from Table I that the proportion of the parent seed sources is strongly reflected in the seedling population. Apparently in this non-old field situation, Virginia pine is as likely to successfully invade as loblolly pine.

Vegetation Analysis: Sampling data are presented in Table II. Relative dominance for all trees  $> 1"$  dbh, relative density of overstory trees ( $> 6"$  dbh), relative density for understory ( $> 1"$  dbh,  $< 6"$  dbh) trees, and stems per hectare for each stratum are recorded for each stand. Stands 3, 4, 7, and 8 are clearly dominated by loblolly pine. Stands 1, 2, 5, and 6, however, are a fairly even mixture of the two species. This verifies the reported history/composition relationship: abandoned fields allowed development of nearly pure loblolly stands, whereas only cut-over areas allowed mixed stands to develop. The mixed (cut-over) stands have a greater diversity of hardwood species present than the loblolly (old-field) stands. This is because, stump sprouts, and relict seedlings and saplings of hardwoods would be left in cut-over areas, but be absent from abandoned fields. Despite greater abundance in cut-over areas, none of the hardwood species seemed associated more with one type of pine stand than another.

Soil Moisture: Table III shows results of average percent soil moisture readings for spring (May-June), summer (Aug.-Sept.), and fall (Oct.-Nov.) for each of the 8 stands. Three of the loblolly-dominated stands are consistently more moist than the four mixed stands, a difference which might be critical in very dry summers like that of 1976. However, one of the loblolly stands is just as dry as the mixed stands.

Soil Texture, pH, and Mineral Content: Table III gives results of the soil analysis. All 4 loblolly stands have slightly higher pH than all mixed stands and two loblolly stands have higher  $K_2O$  than any mixed stands, but the other two did not. No other patterns are discernible between the two groups. Surprisingly, the driest stands in each group are also the least sandy in their group, which is the reverse of the conventional expectation.

### Discussion

Soil fertility seemed a reasonable possibility as a controller of distribution in these two pines, even though it was previous land use that correlated with their abundances. The cut-over areas obviously had been allowed to grow into pine forest that was old enough to be harvested before the current generation of pines was established. As agricultural land use was declined, less fertile areas would probably have been abandoned first, so natural fertility might be higher in the most recently abandoned (old field) stands. Further, artificial fertilization should

Table II. Vegetational composition of studied stands.  
Only major species are included.

Stand Type	Cut-Over											
Stand No.	1 (Longhill 1)			2 (Longhill 2)			6 (Hidden Estate)			5 (Jolly Pond)		
	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"
<i>Pinus taeda</i>	41.6	45.2	8.5	27.3	41.5	5.1	15.7	50.0	3.3	20.4	25.0	18.9
<i>Pinus virginiana</i>	34.5	46.8	3.4	31.8	31.0	-	37.3	33.1	29.7	68.5	25.0	75.4
<i>Liquidambar styraciflua</i>	3.1 <sup>1</sup>	-	1.7	-	3.5 <sup>1</sup>	-	17.6	16.6	19.8	-	-	1.9
<i>Liriodendron tulipifera</i>	7.7	4.8	5.1	-	-	2.6	2.0	-	3.3	-	-	-
<i>Nyssa sylvatica</i>	1.5	-	20.3	4.5	-	41.0	-	-	-	1.8	25.0	-
<i>Cornus florida</i>	-	-	10.1	-	-	-	-	-	5.5	-	-	-
<i>Prunus serotina</i>	-	-	1.7	-	-	-	-	-	-	-	-	-
<i>Quercus falcata</i>	1.5	1.6	-	2.3	3.5	2.6	11.8	-	11.0	3.9	25.0	-
<i>Ilex opaca</i>	3.1	-	13.6	-	-	-	-	-	2.2	-	-	-
<i>Oxydendron arboreum</i>	1.5	-	10.3	-	-	-	3.9	-	-	-	-	-
<i>Quercus alba</i>	-	-	5.1	25.0	20.6	18.0	-	-	1.1	1.8	-	-
<i>Carya tomentosa</i>	1.5	1.6	8.5	4.5	-	12.8	-	-	-	-	-	-
<i>Carya pallida</i>	-	-	-	4.5	-	12.8	-	-	-	-	-	-
<i>Diospyros virginiana</i>	-	-	-	-	-	-	-	-	-	-	-	-
Stems/ha	-	684	2611	-	480	2583	-	296	4483	-	312	4141

Stand Type	Old Field											
Stand No.	3 (Centerville L)			8 (College Woods)			4 (Centerville R.)			7 (Waller Mill)		
	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"	Rel. Dom.	Rel. Dens. > 6" dbh	Rel. Dens. 1-6"
<i>Pinus taeda</i>	100	100	75.0	99.3	98.9	42.4	94.5	95.9	34.4	93.9	93.8	20.8
<i>Pinus virginiana</i>	-	-	3.6	-	-	-	5.5	4.2	2.1	0.8	2.1	2.1
<i>Liquidambar styraciflua</i>	-	-	10.7	-	-	7.6	-	-	18.8	-	-	20.8
<i>Liriodendron tulipifera</i>	-	-	3.6	0.7	1.1	28.3	-	-	6.3	-	-	4.2
<i>Nyssa sylvatica</i>	-	-	-	-	-	2.2	-	-	-	-	-	2.1
<i>Cornus florida</i>	-	-	-	-	-	8.7	-	-	12.5	-	-	4.2
<i>Prunus serotina</i>	-	-	-	-	-	1.1	-	-	4.2	1.5	2.1	12.5
<i>Quercus falcata</i>	-	-	-	-	-	-	-	-	2.1	-	-	-
<i>Ilex opaca</i>	-	-	-	-	-	-	-	-	-	-	-	8.3
<i>Oxydendron arboreum</i>	-	-	-	-	-	-	-	-	6.3	-	-	-
<i>Quercus alba</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carya tomentosa</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carya pallida</i>	-	-	-	-	-	-	-	-	2.1	-	-	-
<i>Diospyros virginiana</i>	-	-	-	-	-	-	-	-	-	-	-	14.6
Stems/ha	-	824	1647	-	1328	793	-	776	1069	-	781	518

1. Because dominance and density are measured separately in the combined Bitterlich/circular quadrat method, species may be encountered only in one column or the other.

Table III. Available moisture, pH, mineral content, and soil texture in 8 sampled stands.

Stand #	Old Field (loblolly)				Out-over (mixed)			
	3	4	8	7	1	2	5	6
% available soil moisture								
May-June	98.5	99.5	99.	67.7	69.	85.	74.	45.7
Aug.-Sept.	33.8	11.5	16.5	1.25	1.25	0	2.50	3.75
Oct.-Nov.	100.	100.	100.	97.25	97.75	96.5	95.5	93.13
pH	4.55	4.7	5.0	4.8	4.5	4.08	4.12	4.33
mineral content (lbs/acre)								
CaO	151.25	165.	275.	110.	206.13	158.	169.84	134.13
MgO	15.5	16.	60.5	26.	32.25	14.	21.	15.75
P <sub>2</sub> O <sub>5</sub>	25.75	18.5	17.75	16.	12.50	17.75	16.	28.38
K <sub>2</sub> O	37.25	50.5	69.	63.	44.75	35.5	48.	30.13
soil texture:								
% Sand	86.79	83.5	84.31	57.69	84.	87.88	84.	69.75
% Silt	9.43	10.4	11.76	36.54	13.12	3.03	14.	20.
% Clay	3.78	4.	3.93	5.72	2.8	8.00	2.	1.05



affect the mineral content of old fields so that at least in the earlier years after abandonment, when pine seedlings are being established, they might be more fertile than a cut-over forest stand long removed from cultivation. While Oosting (1942) noted that "chance of seeding" determined to a large extent the local distribution of species in pine stands, with both Virginia and loblolly pine exhibiting equal vigor wherever they start, Oosting (1942) did note a certain degree of differential distribution: loblolly is most often found on the "best" sites, and Virginia pine on the "poorest" sites. According to Collingwood (1938) Virginia pine will indeed invade abandoned fields, but persists only on the "more sterile", sand and clay areas of its range". Fowells (1965) also mentions the superior aggressiveness of Virginia pine on poor sites. The species would thrive on moist, fertile soils, but as Collingwood (1938) stated, competition from other species here prevented survival of pure stands, leaving only scattered Virginia pines. It can be inferred that, where seed source is adequate at a given site, Virginia pine will be most likely to successfully invade under poor conditions, where it is a relatively better competitor than species less tolerant of poor soil.

Not all data support this scenario. Not only did McQuilken (1940) assess site factors as minor in their influence on local distribution of these two species, but Fowells and Krauss (1959) reported no difference between these two species in nitrogen and phosphorus requirements. The results of our study offer no evidence to refute these latter findings; our data show that soil nutrients and soil texture are similar in both stand types.

McQuilken (1940) indicated that moisture was the major factor other than seed source in establishment, and Hosner & Graney (1970) suggested that further work should be done to determine if the two species have different responses to soil moisture levels. It might be expected that low moisture sites would be among the first to be abandoned by farmers, and therefore the cut-over sites would be drier sites. Three of the old field stands were indeed moister than the four cut-over sites, and this might be interpreted as consistent with Fowells' description of Virginia pine as occurring on moderately well-drained to well-drained soils, with loblolly more important on poorly drained sites. It would also fit well with the idea that loblolly has a competitive advantage on wetter sites, whereas on drier sites it is less aggressive and Virginia pine is able to assume co-dominance. However, the one drier loblolly-dominated old field stand casts doubt on the significance of moisture differences in this study, since it is as dry as the cut-over sites.

Hosner and Graney (1970) have shown that no significant difference of growth of seedlings occurs between Virginia and loblolly pine on either abandoned field sites or climax oak-hickory stands, but they worked only with transplanted seedlings and their conclusion is not necessarily pertinent to our study. Their study did not encompass germination, establishment, or older stages of the two species, which in our case have all taken place under natural conditions. Further work needs to be done to determine whether loblolly gains an advantage in old fields at the time of germination or later.

An explanation is still needed as to why Virginia pine is better able to compete on cut-over areas. Soil fertility cannot be completely ruled out as the factor that tips the competitive balance, since fertility of old field just after abandonment might indeed be higher than 20-30 yrs after abandonment. While there is no convincing evidence in our data that soil moisture is crucial to the competitive balance, some interaction of moisture and other factors may be involved. Is it possible that litter on the timbered sites (which would not be on an old field) diminishes the success of loblolly reproduction but not that of Virginia pine, allowing the latter to gain a foothold? Even if it is past land use, rather than some intrinsic factor that determines the competitive balance, the physical or biotic differences caused by the land use and altering the competitive balance need to be discerned. Further work is needed to find answers to these questions.

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**A Rapid and Convenient Procedure for the  
Synthesis of Radiolabeled Di- and Tripeptides**

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**Abstract**

This paper describes a procedure for the rapid synthesis of radiolabeled di- and tri-peptides. The technique makes use of a water soluble coupling reagent and catalytic dehydrogenation for deblocking the synthetic product. The radiolabeled peptide may be obtained in high yield and purity.

**INTRODUCTION**

The field of peptide synthesis has expanded to such an extent over the past decade that the novice who needs only to synthesize the occasional peptide quickly becomes lost in the deluge of possible methodologies to be followed. Fortunately, the availability of a wide assortment of small peptides from commercial sources such as Sigma Chemical Co. (St. Louis, Mo.) has made it possible to buy that occasional peptide unless the researcher needs it to be radiolabeled or modified in some way. Several years ago the authors found it necessary to use small radiolabeled peptides in a research project and were faced with the necessity to synthesize a small number of peptides on a limited budget. This paper is the result of several months of searching for a simple and reliable synthetic procedure for preparing radiolabeled peptides. Much of the individual methodologies have been published elsewhere by others and the value of the procedure presented here lies in the application of such methodologies in the combination described. The readers are referred to the book "Peptides: Structure and Biological Function" by E. Gross and J. Meinenhofer (Pierce Chemical Company, Rockford, Ill.) for an extensive review of peptide synthetic procedures.

The synthetic procedure described in this manuscript may be performed in less than one day and will give yields (up to 80%) of a product which may be used without further purification. The procedure utilizes a water soluble coupling reagent and protecting groups which may be simultaneously removed within 2 to 5 minutes.

**Materials and Methods**

For convenience we have chosen to use synthesis of glycyl-L-leucine and L-leucyl-L-phenylalanine for description of the procedure. The use of amino acids with additional reactive groups would necessitate the use of alternate methodologies.

The carbobenzoxy (CBZ) protected amino acids (or peptides) and amino acid benzyl esters may be purchased from Sigma Chemical Company. Radiolabeled amino acids may be purchased from Amersham Radiochemicals (Arlington Heights, IL) or a similar radiochemical company. If you purchase a radiolabeled amino acid you may find it necessary to con-

<sup>1</sup>This paper is reprinted here because through editorial error portions of the manuscript were omitted when it was published previously.

struct the benzyl ester derivative yourself (see later methods).

The coupling reagent EDC (1-ethyl-3-(3-dimethylaminopropyl carbodiimide) and deblocking reagent, palladium black, may be purchased from Sigma Chemical Company.

#### SYNTHESIS OF BENZYL ESTER DERIVATIVES:

The procedure used for the synthesis of the benzyl ester is essentially that of Zervas, Winitz and Greenstein (1957). The benzyl ester derivatives of selected amino acids are synthesized by mixing the  $^{14}\text{C}$  labeled amino acid (50  $\mu\text{Ci}$ , 165mCi/mole) with a known amount of non-radioactive amino acid (20 mmoles) and adding this mixture to an equal amount (20 mmoles) of p-toluensulfonic acid. Benzyl alcohol (80 mls) and benzene (40 mls) are added and the entire solution refluxed for 8 hours in a Dean & Stark distillation apparatus with the temperature of the reaction never exceeding  $80^\circ\text{C}$ . Upon completion of the reaction the light yellow solution is cooled to room temperature, 500 mls of diethylether added and the entire solution cooled to  $0^\circ - 2^\circ\text{C}$  for 15 hours to precipitate the p-toluensulfonate amino acid benzyl ester. The melting point of the amino acid benzyl ester p-toluensulfonate is checked against the published value ( $158.5-160^\circ\text{C}$  for leucine benzyl ester) (Zervas, Winitz, Greenstein, 1957). The solution is filtered and the precipitate added to chloroform (30 mls) at  $0^\circ\text{C}$  with constant stirring. Triethylamine is then added dropwise until a clear solution results. Ether (400 mls) is added to precipitate the triethyl ammonium p-toluensulfonate and the ethereal solution supernatant concentrated *in vacuo* to approximately 2 mls and saturated with HCL gas to precipitate the amino acid benzyl ester salt.

The purity of the product is determined by melting point analysis, using a Hoover capillary point melting apparatus, and thin layer chromatography.

#### SYNTHESIS OF THE PEPTIDE:

The  $^{14}\text{C}$  - amino acid benzyl ester was used without further purification by dissolving (10 mmoles) in methylene chloride or tetrahydrofuran (5 mls) containing freshly distilled triethylamine (20  $\mu\text{l}$ ) which is used to neutralized the associated HCL. The amount of triethylamine used in any synthesis is dependent upon the amount of benzyl ester used, such that equivalents of each are reacted. An equimolar amount of carbobenzoxy-amino acid (10 mmoles) and 1-ethyl-3-(3 dimethylamino propyl) carbodiimide (10 mmoles) are added and the reaction mixture stirred overnight at room temperature. The reaction mixture is then washed three times with 25 mls of water to remove the water soluble N-acyl urea which is a by-product of the reaction and unreacted CBZ amino acid, and three times with 0.1 N HCL (25 mls) to remove the unreacted benzyl ester. Evaporation of the methylene chloride leaves the yellow oil residue of the carbobenzoxy and benzyl ester blocked peptide (CBZ-L-amino acid - L -  $^{14}\text{C}$  amino acid benzyl ester.)

#### REMOVAL OF PROTECTING GROUPS:

The simultaneous removal of both the carbobenzoxy and benzyl ester protecting groups is accomplished by dissolving the product in 3-5 mls methanol/formic acid (4.4%) and passing the solution over palladium black (50-100 mg) packed in a Pasteur pipette. ELAmin, et al., (1979) reported the rapid removal of such protecting groups by catalytic transfer hydrogenation. Formic acid was shown to be a very effective hydrogen donor for the rapid removal of these peptide protecting groups and a good solvent component, providing complete solubilization of most peptides and peptide derivatives.

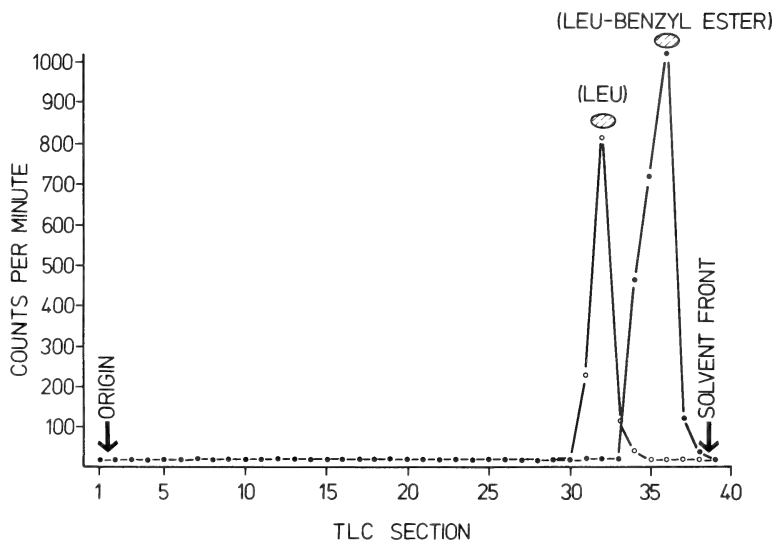


Fig. 1.

Thin layer chromatography of synthesized L-[ $^{14}\text{C}$ ] leucine benzyl ester (0-0) and the product formed following passage of the benzyl ester over the palladium black column (0-0). The oval symbols above each peak of radioactivity indicates the position on the TLC sheet where authentic L-leucine and L-leucine benzyl ester migrated. See Materials and Methods for run conditions.

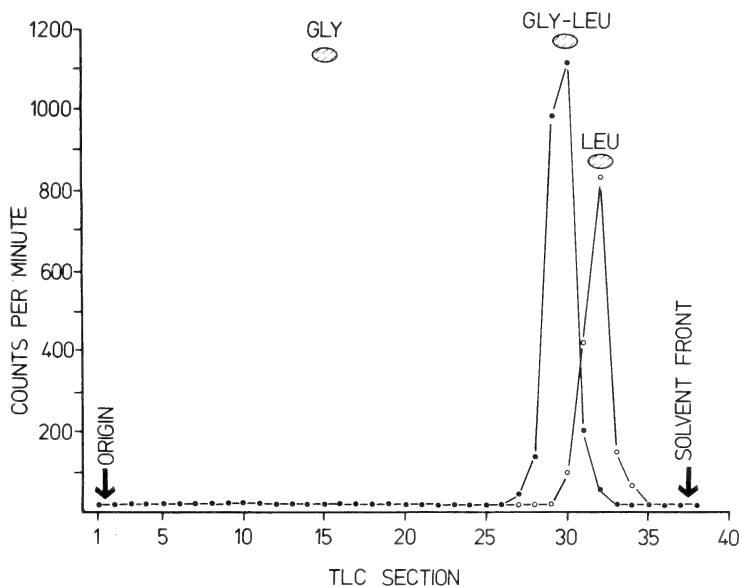


Fig. 2.

Thin layer chromatography of synthesized [ $^{14}\text{C}$ ]-glycyl-L-leucine (0-0) and the radiolabeled product remaining after acid hydrolysis (0-0). The oval symbols above each peak or along the top of the figure indicates the position on the TLC sheet where authentic glycine, glycyl-L-leucine, and L-leucine migrated.

THIN LAYER CHROMATOGRAPHY:

Purity of all benzyl esters and peptides synthesized was confirmed by thin layer chromatography. To test the identity of all synthetic products, cellulose thin layer chromatography sheets (Eastman) were spotted with 10  $\mu$ l aliquots of the appropriate solutions as well as known peptides and amino acids, developed in an ethanol: acetic acid: water (65:1:34; v/v/v) solvent, dried and sprayed with ninhydrin (0.4% solution in acetone).

In addition the peptides were hydrolyzed under vacuum in 6 N HCl at 100°C for 18 hours in sealed tubes. The hydrolysis products were dried under vacuum over KOH, 0.1 ml of water added, 10  $\mu$ l spotted on the TLC sheet, and thin layer chromatography performed using the above procedure.

TNBS ASSAY OF FREE AMINO GROUPS:

Deblocking of CBZ-protected amino groups on peptides was followed by use of the trinitrobenzenesulfonic acid (TNBS) assay. Aliquots of formic acid/methanol solutions of CBZ - blocked peptides and amino acids prior to and following passage over the palladium black column were taken to dryness, redissolved in 1 ml of buffer (0.1 M 2-dimethylamino-ethanol, pH 9.0) and 1 ml of 0.1% TNBS (in water) added. The TNBS was permitted to react for 30 minutes at room temperature prior to addition of 1 ml of 10% sodium dodecyl sulphate (SDS) and 0.5 ml of 1 N HCl. Absorbance was measured at 340 nm using a known concentration of peptide for calculation of concentration of deblocked peptide.

RESULTSSynthesis of benzyl ester:

Synthesis of the L- [ $^{14}$ C] - leucine benzyl ester was essentially as described in the materials and methods. Purity of the product was determined using thin layer chromatography and figure 1 reveals that the benzylolation reaction was essentially 100% complete with no radioactivity remaining at the position ( $R_f$  value of 0.84) of leucine. Catalytic deblocking of L [ $^{14}$ C] leucine benzyl ester using palladium black and methanol/formic acid resulted in complete conversion to L- [ $^{14}$ C] - leucine. The extent of the reaction was determined by thin layer chromatography and scintillation counting and essentially 100% of the L- [ $^{14}$ C] - leucine benzyl ester was converted to L- [ $^{14}$ C] - leucine within 5 minutes (fig. 1).

Peptide synthesis:

Once purity of the L- [ $^{14}$ C] - leucine benzyl ester had been established it could be used, without further purification. Synthesis of the peptide and deblocking as described in the materials and methods yields peptide in 70% to 85% yields as calculated from the recoverable radioactivity. Thin layer chromatographic analysis of an aliquot of the product revealed a single peak of radioactivity at an  $R_f$  corresponding to the peptide synthesized (figs. 2 and 3). Acid hydrolysis (overnight at 100°C in 6 N HCl in a vacuum sealed tube) of each product revealed a single spot of radioactivity on TLC plates which corresponded to free leucine (figs. 2 & 3). Spraying identical plates with ninhydrin revealed two ninhydrin positive spots corresponding to either leucine and phenylalanine or leucine and glycine depending on the peptide hydrolyzed (data not shown).

Time Course of Deblocking:

Although we routinely deblock the synthesized peptides by dissolving them in methanol/formic acid and passing them over a palladium black column we felt it might be informative to examine the rate at which de-

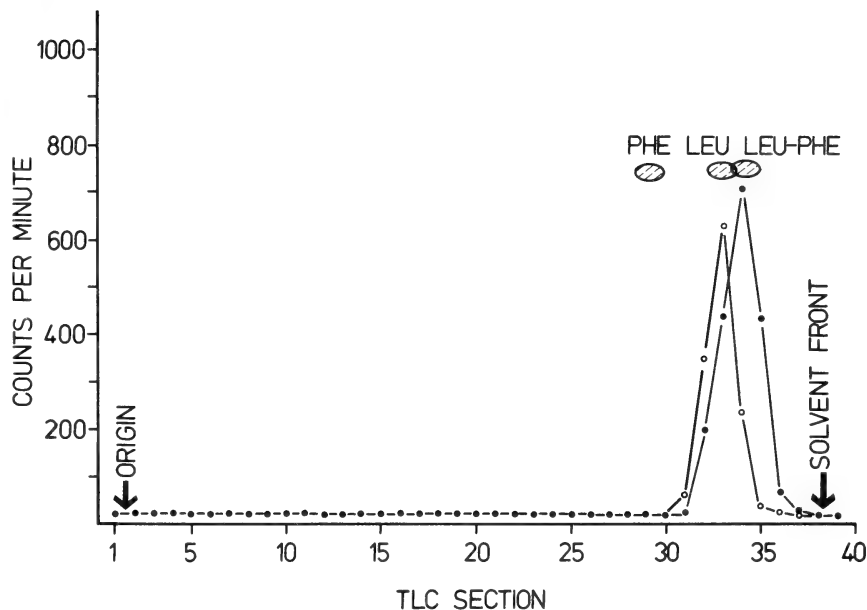


Fig. 3.

Thin layer chromatography of synthesized [ $^{14}\text{C}$ ]-L-leucyl-L-phenylalanine (0-0) and the radiolabeled product remaining after acid hydrolysis (0-0). The oval symbols along the top of the figure indicates the position on the TLC sheet where authentic L-phenylalanine, L-leucyl-L-phenylalanine and L-phenylalanine migrated.

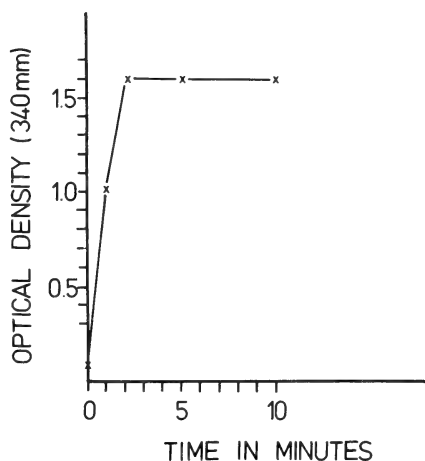


Fig. 4.

Time course of deblocking of CBZ-L-leucine by palladium black and 4.4% formic acid in methanol.

blocking occurs. To do this, we mixed 50 mg of palladium black in 5 mls of methanol/formic acid, added the blocked peptides (or blocked substrates, i.e. CBZ - glycine, etc) and removed aliquots with time. Each aliquot was taken to dryness and analyzed for free amino groups using the TNBS assay described in the materials and methods. Figure 4 shows the appearance of free amino groups (increased optical density at 340 nm) with time. The deblocking of CBZ-L-leucine was essentially 100% complete within 2 minutes (fig. 4).

#### DISCUSSION

The synthetic procedure described in this paper is not the only or even the best procedure for the synthesis of small radiolabeled peptides. However, the various techniques and reagents employed should facilitate the synthesis of such peptides by researchers who do not wish to become extensively involved in peptide synthesis. All reagents are commercially available and each step in the procedure may be undertaken using equipment available in most laboratories.

The reagent DCCD (dicyclohexylcarbodiimide) typically employed in this reaction yields a water insoluble dicyclohexylurea product which is difficult to remove from the reaction mixture. The EDC urea derivative is soluble in water and is easily removed along with unreacted substrates by the initial washings of the hydrophobic peptide product.

The use of carbobenzoxy and benzyl ester derivatives provides end group blocked peptide products which may be rapidly and completely deblocked by palladium black. ElAmin, et al. (1979) first reported the rapid removal of these protecting groups by catalytic transfer hydrogenation. The formic acid was shown to be a very effective transfer hydrogen donor as well a good solvent for most peptides and peptide derivatives. The concentration of formic acid may be varied, but 4.4% proved to be most effective in deblocking a broad spectrum of protected substrates.

#### ACKNOWLEDGEMENTS

Portions of this research were supported through a grant to L. Wolfinbarger by the Virginia Academy of Sciences.

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2. Zervas, L., M. Winitz, and J. P. Greenstein, 1957. Studies on arginine peptides I. Intermediates in the synthesis N-terminal and C-terminal arginine peptides. *J. Org. Chem.* 22:1515-1521.



## Errata: Bell, Bovard and Stratton

The paper "Changes in Balance and Hand-Eye Coordination in Educable Mentally Retarded Adults as a Result of an Eight-Week Swimming Program" by G. H. Bell, Ken Bovard, and R. K. Stratton (V.J.S. 33 (2): 7-10; August 1982), contains an error in the statistical analyses shown in table 2. The proper error term for sex is subject within sex, not the error mean square, as originally presented. Following this change in the analysis, the probability values,  $P > F$ , for the statistical significance of sex, both corrected and former, are: for OFFBAL, reduced to .07 from .0001; for TOB, reduced to 0.62 from 0.27; and, for TTC, reduced to 0.27 from 0.046. This has the net effect of reducing the relative importance (statistical significance) of sex from very large to borderline, from possible to doubtful, and from borderline to possible, respectively. Clearly, sex differences cannot be presumed to be real. Repetition and refinement of this work are needed to clarify this question.

The authors wish to acknowledge Dr. Klaus Hinkelmann, Head, Statistics Department, Virginia Tech for identifying and correcting the error cited above.

## Announcement: Research Grants

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Members of the Virginia Academy of Science May apply for small project grants to support their research. These grants are usually in the amount of \$500 or less and are available to support any field of research. There are two deadlines for receipt of applications, March 15 and October 15, each year. For application forms and further information, contact:

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FALL 1983

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# VIRGINIA JOURNAL OF SCIENCE

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# THE VIRGINIA JOURNAL OF SCIENCE

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The original and two copies of each manuscript and of all figures therein are required. *Authors should submit names of three potential reviewers.* **All manuscripts must be double-spaced throughout. The title, author's name, affiliation and address should be placed on a covering page. An abstract (on a separate sheet) summarizing the text, particularly the results and conclusions, is required. After revision and final acceptance of an article, the author will be asked to furnish an error-free, camera-ready copy of the manuscript typewritten single-spaced with a black carbon ribbon on white bond paper.**

The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year format: Fujishima and Honda (1972), or Spry (1969), or Guliday (1971). On the Literature Cited page at the end of the article each reference should include author(s), year, *title of article*, title of journal (using standard abbreviations), volume number, and first *and last* page of the article. For a book, include author(s), year title, pages or number of pages, and publisher and city of publication. Examples:

Fujishima, A., and Honda, K. 1972. Electrochemical Photolysis of Water at a Semiconductor Electrode. *Nature* 238: 37-38.

Spry, A. 1969. *Metamorphic Textures*. Pergamon Press, New York. 350 pp.

Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. *In* *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.). pp. 223-262. VPI & SU, Blacksburg, Va.

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# VIRGINIA JOURNAL OF SCIENCE

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**Abstracts of Papers Presented at the  
Sixty-first Annual Meeting, Virginia Academy of Science  
May 17-20, 1983, George Mason University, Fairfax**

**Aeronautical and Aerospace Science Section**

STEADY HYPERSONIC ROTATING FLOW PAST A SLENDER BODY. R. J. Barbarsky\* and Houston G. Wood, III, Dept. of Mech. and Aerosp. Engrg., Univ. of Va., Charlottesville, VA 22901. The steady, hypersonic, rotating flow of a perfect gas past a slender, stationary body represents a problem of considerable interest from a basic fluid mechanics viewpoint. The object of the proposed research is to use hypersonic flow theory to develop a semianalytical model of the flow by considering the inviscid solution matched to a boundary-layer type viscous solution. The Newtonian approximation for inviscid flow is made in the course of the development. The inviscid problem appears to be amenable to similarity methods developed for nonlinear partial differential equations, while an asymptotic solution of the Prandtl boundary layer equations will be sought for the regions of "strong" and "weak" interaction of the shock and the viscous layer. Finally, conditions may be derived which permit the details of the flow in the neighborhood of the body to be replaced by a boundary condition to be imposed on the external flow field as predicted by Onsager's Pancake model.

VIDEO MODEL DEFORMATION SYSTEM FOR THE NATIONAL TRANSONIC FACILITY. A. W. Burner\*, W. L. Snow\*, and W. K. Goad\*, NASA, LaRC, Hampton, Va. 23665. The National Transonic Facility through a combination of cryogenic temperatures and high pressure will subject models to heavier aerodynamic loads than are usually experienced in existing transonic facilities. Furthermore, the unique characteristics of this tunnel will allow independent variation of dynamic pressure while holding other critical aerodynamic variables fixed. Non-intrusive methods to measure model deformation thus become an important instrumentation consideration. Photogrammetry has been chosen as a suitable technique to determine deformation over an entire wing without scanning or requiring multiple single-point systems. Limited tunnel access dictated the selection of high resolution video instead of conventional film cameras to record data. The CCTV based measurement system to be used in the NTF in the Fall of this year will be described.

AERODYNAMIC INTERFERENCE CALCULATIONS FOR AN AIRCRAFT WITH A PROPPAN. B. Chandrasekaran\* and Sudhir C. Mehrotra, Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666. A subsonic-flow panel code has been modified to handle the effects of a propeller wake. The effects of the propeller were modelled by a system of ring vortices of constant strength. Principles based on the blade element theory and the momentum theory were used to evaluate the swirl velocity and the pressure increase, across the propeller. Experiments are defined and model details are given. The experimental results are compared with the theory. The discrepancies between the calculated and measured quantities are analysed. Improvements to enhance the accuracy of the theoretical prediction are indicated.

DETERMINING REYNOLDS NUMBER EFFECTS ON FLUTTER. Stanley R. Cole,\* NASA Langley Research Center, Hampton, VA 23665. The effects of high Reynolds number on aeroelastic phenomenon are being studied to determine the need for aeroelastic wind-tunnel testing in the National Transonic Facility at NASA Langley Research Center when it becomes operational. The present study is an attempt to determine the effects of Reynolds number on flutter. A model has been designed for testing in the 0.3-m Transonic Cryogenic Tunnel (TCT). The 0.3-m TCT is also capable of obtaining high Reynolds numbers. The model consists of a relatively rigid wing supported by a flexible shaft. A preliminary test of a scaled model has been conducted in the Transonic Dynamics Tunnel (TDT) to determine the flutter characteristics of the model before attempting the 0.3-m TCT test. Analytical design of the model, results of the TDT flutter experiment, and plans for the 0.3-m TCT test will be discussed. Cryogenic flutter testing procedures, including subcritical response techniques for predicting flutter onset, will also be discussed.

APPLICATION OF COATED FIBER STUDIES TO SILICON-CARBIDE/TITANIUM COMPOSITES. L. L. Drewry, W. D. Brewer, and J. Unnam. NASA, Langley Research Center, Hampton, Va. 23665

A relatively new silicon carbide fiber (designated SCS-2) has shown potential as reinforcement in titanium matrix composites. As with previous titanium composites, however, the SCS-2/Ti system is subject to property degradation caused by fiber-matrix interactions. An SCS-2/Ti composite system, simulated by sputter-coating individual fibers with titanium, was investigated to characterize these microstructural and chemical interactions that adversely affect material performance. Because aluminum has been shown to be an effective interfacial barrier, an SCS-2/Al/Ti system was also investigated. The coated fibers were exposed to time-temperature environments typical of composite fabrication, tested for tensile property changes, and analyzed by scanning electron microscopy, Auger spectroscopy, and electron microprobe analysis. Measured fiber tensile properties were used to predict composite properties to compare with measured composite properties.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS (ECLSS) TECHNOLOGY ASSESSMENT FOR MANNED SPACE STATIONS. John B. Hall, Jr. and Shelby J. Pickett\*, NASA Langley Research Center, Hampton, Va. 23665. The synthesis of an Earth-orbiting space station to enhance man's permanent presence in space requires the assessment of ECLSS technology options from which to select the most promising subsystem candidates for space station development. This presentation gives a description of a computer-aided technology assessment program developed at the NASA Langley Research Center to aid in selecting those options which significantly reduce the crew resupply requirements for metabolic oxygen and potable water. The data base and methodology are presented which provide the basis for the assessments as functions of crew size, mission duration, resupply interval, and life cycle costs.

APPLICATION OF A LASER RESONANCE DOPPLER VELOCIMETER AT THE NASA LANGLEY RESEARCH CENTER 3-INCH HYPERSONIC HELIUM TUNNEL. John C. Hoppe, Instrument Res. Div., Langley Res. Ctr., Hampton, Va. 23665. Laser-induced fluorescence can be used to provide measurements of mean velocity high speed flowing gases. A system to accomplish such measurements has been implemented at the Langley Research Center's 3-inch hypersonic helium tunnel. Free stream velocities in that facility are approximately 1.5 to 2.0 km/sec. The method, developed at Princeton Univ.<sup>(1)</sup>, includes seeding the flow with sodium atoms. The sodium absorbs incident visible radiation from a tunable dye laser, and emits D-line resonance fluorescence. The optical frequency of that emitted fluorescence is compared to a similar induced emission from an atomic beam source, to permit the velocity-dependent Doppler shift to be measured. Preliminary data are presented.

<sup>(1)</sup> R. B. Miles and M. Zimmerman, Final report for NASA Grant NSG 1070, Princeton Univ. Dept. Mech. Aerospace Eng., Report No. T-1465, March 1980.

## INVESTIGATION OF FAST INITIALIZATION OF SPACECRAFT BUBBLE MEMORY SYSTEMS.

Karen T. Looney\* and Paul J. Hayes,\* NASA Langley Research Center, Hampton, VA 23665, Mail Stop 470. Bubble domain technology offers significant improvement in reliability and functionality for spacecraft onboard memory applications. In considering potential memory system organizations, minimization of power in high capacity bubble memory systems necessitates the activation of only the desired portions of the memory. In power strobing arbitrary memory segments, a capability of fast turn-on is required. Bubble device architectures, which provide redundant loop coding in the bubble device, limit the initialization speed. Alternate initialization techniques have been investigated to overcome this design limitation. An initialization technique using a small amount of external storage has been demonstrated. This technique provides several orders of magnitude improvement over the normal initialization time.

## QUASI-VORTEX-LATTICE METHOD FOR WINGS WITH EDGE VORTEX SEPARATION. Jenn-Louh Pao\*

Vigyan Research Associates, Inc., 28 Research Drive, Hampton, VA 23666. An improved vortex filament-vortex core method for predicting aerodynamic characteristics of slender wing with edge vortex separation has been developed. Semi-empirical but simple methods are used to determine the initial position of the free sheet and vortex core. Comparison with available data indicates that: (1) the present method is generally accurate in predicting the lift and induced drag coefficients but the predicted pitching moment is too positive; (2) the spanwise lifting pressure distributions estimated by the vortex core solution of the present method are significantly better than the results of Mehrotra's method to the pressure peak values for the flat delta; (3) the two core system applied to the double delta and strake wing produce overall aerodynamic characteristics which have good agreement with data except for the pitching moment; (4) the computer time for the present method is about two third of that of Mehrotra's method.

RESIDUAL STRESS MEASUREMENT BY HOLE DRILLING METHOD IN ORTHOTROPIC MATERIALS USING PHOTOELASTIC COATINGS. R. Prabhakaran and C. B. Prasad, Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, VA 23508. The applicability of photoelastic coatings, in conjunction with the hole-drilling method, to the determination of residual stresses in relatively thin orthotropic materials was investigated. The birefringent response on the boundary of a small hole drilled in an orthotropic material was calculated as a function of the principal stress-ratio for the particular case when the principal stress directions coincided with the material symmetry axes; the stress distribution is known from Lekhnitskii's solution. It is shown that the residual stresses can be determined by measuring the birefringent response at selected points on the hole-boundary and using calibration constants determined for simple specimens.

## STABILITY ANALYSIS OF THE COMPRESSIBLE EKMAN LAYER. John R. Spall\* and

Houston C. Wood, III, Dept. of Mech. and Aerosp. Engrg., Univ. of Va., Charlottesville, VA 22901. A linear stability analysis of a compressible Ekman boundary layer on a rotating disc is presented. The equations of motion are reduced to solving an eigenvalue problem for the growth rates. A numerical solution is obtained using the shooting method. The rotation speed at the periphery of the disc is used to define a Mach number for the gas of interest. A Reynolds number is defined using the local boundary layer thickness and geostrophic flow velocity. For low Mach numbers, two wave types, called A and B waves, appear at Reynolds numbers of approximately 55 and 115 which is similar to the incompressible case. As the Mach number is increased above 7 for air, a new type of wave emerges at a Reynolds number of approximately 62. Numerical studies have shown that prescribing an adiabatic boundary condition on the rotating surface tends to be destabilizing with the critical Reynolds number reduced by a factor of three in some cases.

OXIDATION OF COMMERCIALY PURE TITANIUM. J. Unnam and R. N. Shenoy\*, Vigyan Research Associates, Inc., Hampton, VA 23666. Titanium is an excellent candidate material for thermal protection systems in hyper-velocity vehicles. Oxidation and oxygen embrittlement are the primary considerations in its potential use at temperatures above 1000°F. Air contamination studies have therefore been carried out on a commercially pure titanium in the temperature range of 1100-1400°F. Total oxidation kinetics were determined by thermogravimetric method, oxide thickness was estimated by X-ray diffraction and microscopy, and oxygen depth profiles were deduced from microhardness measurements on the specimen cross-section. Based on these data, a model for the oxidation of titanium is proposed.

IMPACT PROBE RAREFACTION EFFECT MEASUREMENTS IN CO<sub>2</sub> FLOWS. David J. Yurkanin\* and Sam S. Fisher, Dept. of Mech. and Aerosp. Engrg., Univ. of Va., Charlottesville, VA 22901. The effect of flow rarefaction upon the pressure sensed by an open-ended, tube-type impact pressure sensing probe immersed in supersonic CO<sub>2</sub> flow is examined experimentally. Experiments are carried out in free-jet gas expansions into a vacuum chamber. Measurements are obtained as a function of probe Reynolds number, free-stream Mach number, probe length-to-diameter ratio, and ratio of probe to flow stagnation temperature. Results are considered in terms of the ratio of measured-to-ideal impact pressure,  $\hat{p}_i$ . At sufficiently high Reynolds numbers,  $\hat{p}_i$  approaches unity. At sufficiently low Reynolds numbers,  $\hat{p}_i$  approaches its predicted free molecule flow limit (usually large compared to unity). Observed behaviors at intermediate Reynolds numbers are explained. Because CO<sub>2</sub> is vibrationally frozen in these flows, the data obtained are found to be in good agreement with previous results for air and nitrogen. Flow diagnostics applications for these probes and extensions of observed behaviors to other flow conditions are discussed.

## Agricultural Sciences Section

POPULATION STRUCTURE AND ANGLER HARVEST OF SMALLMOUTH BASS UNDER DIFFERENT REGULATIONS IN THE NEW RIVER. Douglas J. Austen\* and Donald J. Orth. Dept. of Fisheries & Wildlife Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. A 305 mm (12-inch) minimum length limit exists for the angler harvest of smallmouth bass (*Micropterus dolomieu*) in the New River from Claytor dam, Va., to the West Virginia border. West Virginia has no minimum length limit and both states have a daily creel limit of 8 smallmouth bass per angler. Angler harvest and catch and release of smallmouth bass was investigated as well as age structure, growth, food habits, proportional stock density, and condition. A total of 357 anglers were interviewed who had fished an average of 4.1 hours (VA) and 3.3 hours (WV) when interviewed. Virginia anglers harvested an average of 0.11 smallmouth bass per hour and released 1.54 bass per hour whereas West Virginia anglers harvest 0.61 smallmouth bass per hour and released 1.05 bass per hour. Average length of smallmouth bass harvested was 317 mm for Virginia and 242 for West Virginia.

OVIPOSITION TIME IN JAPANESE QUAIL AND RELATED PRODUCTION TRAITS. W. L. Beane, C. L. Bish\* and F. E. Robinson\*, Poultry Science Dept., VPI&SU, Blacksburg, Virginia 24061. In the Japanese quail populations used in this study, eggs from the white egg producers tend to have weaker shells than those from pigmented egg producers. To determine if time of lay or time interval between ovipositions is associated with this difference, eggs from 144 birds of each egg color group were observed for a 15-day period for time of lay, time interval between consecutive eggs, egg weight, specific gravity, and weight of shell with membranes. Analyses of data, with intervals over 36 hours deleted, showed no difference in average time intervals between the white and pigmented egg groups (24.7 vs 24.6 hr) or the average time of lay (4:07 vs 4:02 pm). The following measurements were found to be significantly different between the white and pigmented egg groups, respectively: egg weight (11.80 vs 11.89 g); specific gravity (1.0715 vs 1.0766); shell weight (.832 vs .918 g); and percent shell (7.07 vs 7.74). Interval between ovipositions was positively correlated with egg weight, shell weight and percent shell, whereas time of lay was negatively correlated with these traits. However, since no differences between the two egg color groups were noted for time of lay or interval between eggs, the difference in shell quality was not due to these factors.

USING WILLHAM'S COMPUTER PROGRAM TO TEACH GENETIC SELECTION PRACTICES IN BEEF CATTLE: TWENTY-FIVE YEARS' RESULTS IN THREE WEEKS' CLASS TIME. K. P. Bovard, An. Sci.; G. L. Nunn, Computing Ctr.; M. L. McGilliard, Dairy Sci.; and, G. L. Minish, An. Sci., Virginia Tech, Blacksburg 24061. In 1970, Prof. R. L. Willham, An. Sci. Dept., Iowa State Univ., Ames developed a computer program that simulated a beef cattle breeding operation. For the 1983 Winter qtr. 115 students in the beef prod'n class, AnSc 4040 at Va Tech, used the Willham program as a class exercise. Thirty-five herds of 50 cows and 5 sires, each, were simulated, and assigned to teams of three students, each. Both genetic and environmental variation were simulated in five traits, including a random 5% mortality. For each calf crop computer output included calves' pedigrees and performance; progeny performance ave's of sires and dams; estimated breeding values (EBV's) and accuracy; and actual BV's. Final grades for the exercise were determined partly on the basis of change in herd performance levels effected by selection. Computer costs were less than one dollar per student.

MODELING OF AGRICULTURAL OPERATIONS. Nelson L. Buck,\* David H. Vaughan, and Harold A. Hughes.\* Dept. of Agricultural Engineering, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. The simulation language SLAM allows the physical layout of a farm and the sequence of operations in a forage harvesting operation to be combined in a graphical representation called a network. Entities representing equipment move through the network. The arrival of equipment at certain points calls FORTRAN programs that calculate the transfer of materials and consumption of resources. The model allows different harvesting procedures to be compared as to resource requirements and value of the harvested crop. The model makes use of established formulas for its calculations and is verified by comparison of its predictions to data collected during an actual harvest. Where there may be doubt about the accuracy or validity of formulas used, the sensitivity of the model to those formulas is analyzed. Applications of the model in research include the evaluation of new techniques before expensive field trials are run. Applications in farm management include aiding in the selection of machinery and suggesting improvements to operating procedures.

USE OF OVARIAN 20-ALPHA HYDROXY STEROID DEHYDROGENASE ACTIVITY AS A MARKER FOR THE ONSET OF PARTURITION IN RATS. George E. Bunce, Eric A. Gordon, Dept. of Biochemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Ovarian 20-alpha hydroxy steroid dehydrogenase transforms progesterone, which during pregnancy maintains the uterine lining and prevents uterine contractions, into an inactive hydroxylated form. Following the withdrawal of the protective influence of progesterone, other hormones can act on the uterus to induce parturition. Evaluation of this ovarian enzyme shows a rise in enzymatic activity from non detectable levels about 24 hours before parturition to maximum levels at parturition. Pregnant rats fed a low Zn containing diet show a delay in delivery time as compared with control (normal Zn) diet populations. We have also seen a concomitant delay in the time at which ovarian enzymatic activity first becomes detectable in the low Zn population as compared to the control populations. Thus it appears that quantification of 20-alpha hydroxy steroid dehydrogenase activity is a reliable marker for impending parturition in rats.

COMPATIBLE CUBIC VOLUME AND BASAL AREA PROJECTION EQUATIONS FOR THINNED OLD-FIELD LOBLOLLY PINE PLANTATIONS. Harold E. Burkhart and Peter T. Sprinz, Dept. of Forestry, Va. Polytechnic Inst. & State Univ., Blacksburg, VA. 24061. Compatible equations for predicting cubic volume and basal area growth were developed by simultaneously estimating the coefficients in both models. The simultaneous estimation procedure gave stable estimates for the basal area projection equation regardless of the merchantability definitions imposed in the volume projection equation. Prediction equations were fitted using the simultaneous estimation procedure with growth data from thinned loblolly pine plantations established on old-field sites in the Piedmont and Coastal Plain of Virginia.

PREDICTION OF FOREST TYPES IN SOUTHWEST VIRGINIA USING TOPOGRAPHIC INFORMATION. Michael L. Fies\*, Dept. of Fish. & Wildl. Sci., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061, & R. H. Giles, Jr.\*, Dept. of Fish. & Wildl. Sci., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061. Vegetation mapping has traditionally been a tedious yet necessary task for wildlife managers. Aerial photography with subsequent ground truthing has been used most often in large forested areas. In this study, a technique was developed to predict forest cover types using topographic information. Elevations, slopes, aspects, and topographic shapes were incorporated into a dichotomous key to determine the forest type most likely to occur in a 3-acre map cell. Classification accuracy was between 75 and 80 percent. Results suggest that a computerized geographic information system could be used to map large areas at a low cost.

MAXIMUM YIELD RESEARCH ON CORN. D. L. Hallock, F. S. Wright\*, P. H. Reid and N. L. Powell\*. Tidewater Res. and C.E.C., USDA ARS, VPI&SU, Suffolk, VA 23437. Machine planted corn yields averaged as high as 244 bu/a in irrigated corn grown in 15-in wide rows having a population of 35,138 plants/a in tilled soil fertilized as indicated below. Corn emerged after planting more quickly and was 8 in taller 60 days after planting in tilled than no-till plots. Yields were 21 bu/a higher in 15-in than in 30-in wide rows. Row width variance did not affect average ear weight. Average yields were similar in plots fertilized at 75% as in those fertilized at 150% of the following rate in lb/a: 508 N, 128 P, 270 K, 141 S, 67 Ca, 33 Mg, 1.5 B, 3 Mn, 2 Zn, and 0.6 Cu. Total dry matter production varied among plant populations as follows: 37,099 > 42,906 or 32,093 > 19,965. Stalk barrenness was much higher at 42,906 plants/a than for the three lower populations. Individual plots which yielded more than 250 bu/a had more uniform plant emergence and within row spacing than plots which yielded less than 200 bu/a. Highest plot yield was 286 bu/a.



ABSOLUTE DENSITY SAMPLING FOR OVERWINTERING ADULT ALFALFA WEEVIL, HYPERA POSTICA (COLEOPTERA: CURCULIONIDAE). Daniel J. Hilburn, Dept. of Entomol., Va. Polytechnic Inst., Blacksburg, Va. 24061, & W. A. Allen, Dept. of Entomol., Va. Polytechnic Inst., Blacksburg, Va. 24061. A new sampling device has been developed for measuring absolute densities of overwintering alfalfa weevil populations. The hand-operated device collects stubble, litter, and soil to a depth of 3 cm in a .05 m<sup>2</sup> area. Adult alfalfa weevils and a variety of other insects can be extracted from the samples with Berlese funnels.

EFFECTS OF ELECTRICAL STIMULATION ON BROILED BEEF FLAVOR AS MEASURED BY THE RBU SYSTEM. C. L. Hanson, R. F. Kelly, R. W. Young, K. P. Bovard, and P. P. Graham. Depts. of Food Science & Technology, Biochem. & Nutr., and Animal Sci., Va Polytechnic Inst., Blacksburg, Va. 24061. One side of five beef carcasses of similar quality was subjected to 18 electrical pulses of 550 volts for 30 seconds. The opposite sides served as controls (NES). Thirteenth rib steaks from both sides were cooked in a research broiler unit (RBU) and evaluated by a sensory panel. During cooking, headspace volatiles and drippings were collected, prepared and analyzed by GLC for fatty acids and aromatic compounds. Differences due to animal, treatment (ES vs NES) and test samples (volatile vs drip) were small and non-significant ( $P > .05$ ). However, the stearic acid value for ES samples was 3.8% as opposed to 2% for NES samples ( $P > .09$ ). Differences in sensory panel results due to ES were non-significant but the effect of ES on aroma and overall acceptability approached significance ( $P > .13$ ).

ECOLOGICAL INSIGHTS INTO EASTERN RED CEDAR (JUNIPERUS VIRGINIANA L.) AS AN AGRICULTURAL PEST IN VIRGINIA. A.M.A. Holthuijzen\* and T. L. Sharik, Dept. Fish. and Wildl. Sci. and Dept. Biol., VPI & SU, Blacksburg, VA 24061. Red cedar is one of the first woody species invading abandoned pastures in Virginia and is considered a serious pest by farmers. Red cedar stands can be fully stocked in six years on undisturbed, abandoned pastures. Rapid invasion of pastures is induced by endogenous dispersal of seeds by avian dispersers. Flock feeding bird species play an important role in red cedar seed dispersal and several of these species (e.g, starling) forage in active pastures. Seeds passed through birds are viable and possess a higher total germination as well as a higher germination rate than untreated depulped seeds. Red cedar seeds apparently do not accumulate in the soil as was established by sampling red cedar stands of increasing age. Burial of red cedar seeds showed that only 16% of the seeds were viable after 8 months. Thus, red cedar regeneration mainly originates from annual seed rains.

EFFECT OF BREED OF SIRE AND GRANDSIRE ON THE PERFORMANCE OF THREE-BREED-CROSS COWS. Gretchen Kirsch\* and Thomas J. Marlowe, Virginia Tech., Blacksburg 24061. Data were available on 315 matings from a larger study of cow types. Sire breeds of these cows were Angus (A), Shorthorn (Sh) and Simmental (Sm). Sire differences were significant for weaning wt (ww), weaning rate and conformation and condition scores and approached significance for calf mortality ( $P < .07$ ), adj. 205d wt ( $P < .09$ ) and kg calf wn/cow exposed ( $P < .06$ ). Cows by Sh sires weaned more calves and more total calf weight, whereas differences between AA and Sm sired cows were small and nonsignificant. Grandsires of these cows were Angus (A), Shorthorn (Sh), Brown Swiss (BS), Holstein (F), Charolais (C) and Simmental (Sm). Effect of breed of grandsire of cow was significant only for condition of calf at weaning. Calves with C and F grandsires were lowest and Sh calves highest with others intermediate. Differences in kg of calf weaned were nonsignificant but favored F (177 kg) and Sm (181 kg) grandsires with C (157 kg) and BS (158 kg) grandsires the lowest.

EFFECTS OF PLANT GROWTH HORMONES ON OVIPOSITION SITE SELECTION OF LIRIOMYZA TRIFOLII (BURGESS) (DIPTERA: AGROMYZIDAE) J. J. Knodel-Montz\*, S. L. Poe, and R. E. Lyons\*, Dept. of Entomol., Va. Polytechnic Inst. & State University, Blacksburg, VA. 24061. The effects of three plant growth hormones (GA<sub>4</sub>, NAA, B9) and leaf position on oviposition preference of Liriomyza trifolii (Burgess) were measured. All hormones and water (control) were applied as foliar sprays to White Iceberg chrysanthemums. GA<sub>4</sub> (gibberellin aggravator) caused significantly greater ( $P=0.05$ ) mean mine density than controls indicating that GA<sub>4</sub> treatments enhanced oviposition. By contrast, B9 (gibberellin inhibitor) resulted in significantly ( $P=0.05$ ) lower mean puncture densities when compared with controls. On chrysanthemums, lower leaves had significantly higher mine densities and lower punctures densities than upper leaves. Therefore, older leaves are preferred for oviposition while younger leaves are preferred for feeding.

WITHIN PLANT DISTRIBUTION OF THE IMPORTED CABBAGEWORM, ARTOGEIA RAPAE (L.), ON CABBAGE. J. A. Lasota and L. T. Kok, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. The imported cabbageworm, Artogeia rapae (L.), is a major pest of cruciferous crops in southwest Virginia. Frequent applications of chemicals are employed to decrease economic losses to fresh market cabbage plantings. Knowledge of the spatial distribution of the imported cabbageworm within plants is useful in establishing damage threshold levels for reductions in the use of chemicals. Sampling to determine threshold levels can be facilitated by an understanding of the insect life stages and their distribution on the cabbage plant. Recognition of the niche requirements of the imported cabbageworm also aids in studies of parasitism by natural enemies, and population suppression by a naturally occurring granulosis virus. Our investigation shows that variations in oviposition, larval feeding, and pupation sites of the imported cabbageworm are related to changes in season and host phenology. Comparisons of pest population distribution on foliage of prehead versus headed plants exhibited more larvae and pupae on heads than on individual leaves.

CONTINUED EVALUATION OF SALINOMYCIN AS A GROWTH PROMOTANT FOR SWINE. M. D. Lindemann & E. T. Kornegay, Dept. of An. Sci., VPI & SU, Blacksburg, Va. 24061. Four trials were conducted at three locations to evaluate the effects of graded (0, 27.6, 55.1, 82.7 and 110 ppm) levels of salinomycin on the rate and efficiency of growth of swine fed corn-soybean meal based diets. Data were broken into three phases: an initial period of approximately four weeks, a second four week period and, then, the remaining trial period. Pigs fed diets to which salinomycin had been added gained weight faster than control pigs during the first ( $P<.08$ ), second ( $P<.01$ ), third ( $P<.10$ ) and total trial ( $P<.01$ ) periods. The pigs fed added salinomycin diets also gained weight more efficiently during each of the first two periods ( $P<.001$  and  $P<.04$ , respectively) as well as for the total trial period ( $P<.01$ ). For the total trial period (8.8 to 96.1 kg) the average daily gain was 719, 731, 740, 749 and 743 g and feed/gain was 2.94, 2.89, 2.89, 2.82 and 2.87 for pigs fed diets with increasing levels of salinomycin. For the total trial period pigs fed the most efficacious level (82.7 ppm) had a 4.2% improvement in average daily gain and a 4% improvement in feed/gain compared to pigs fed the control diet.

## EFFECT OF THE ADDITION OF PEANUT HULLS TO DIETS FOR GROWING-FINISHING SWINE.

M. D. Lindemann & E. T. Kornegay, Dept. of An. Sci., VPI & SU, Blacksburg, Va. 24061. Two trials were conducted to evaluate peanut hulls (IFN 1-03-629) as a feedstuff for swine. Dietary treatments were 0, 7.5, 15 or 22.5% peanut hulls in a corn-soybean meal based diet. The effects on performance were similar for the growing (28.7 to 60.3 kg), finishing (60.3 to 98.7 kg) and overall trial periods. No differences were observed with respect to average daily gain ( $P>.40$ ). Feed intake ( $P<.05$ ) and feed/gain ( $P<.001$ ) increased linearly as the level of peanut hulls increased in the diet. For the total trial period, average daily gain was 779, 777, 770, and 769 g, average daily feed intake was 2283, 2450, 2483 and 2578 g, while feed/gain was 2.93, 3.15, 3.23 and 3.35, respectively, for pigs fed diets containing 0, 7.5, 15 and 22.5% peanut hulls. Estimates of the contributions of gastrointestinal contents to the final weight were measured by subjecting animals to a 48 hr fast upon completion of the study. Weight loss was greater (linear,  $P<.004$ ) with the incremental additions of peanut hulls to the diet (5.68, 6.73, 6.71 and 7.22 kg, respectively). Using fasted body weight, average daily gain decreased ( $P<.08$ ) linearly (717, 703, 695 and 689 g) and feed/gain increased ( $P<.001$ ) linearly (3.19, 3.49, 3.57 and 3.74) with increasing level of peanut hulls.

## THE COMBINED TOXICITY OF CARBARYL, CHLOROTHALONIL AND MALATHION TO THE COLORADO

POTATO BEETLE, SQUASH SEEDS, AND TOMATO SEEDS. Louis P. Lue, C.C. Lewis, and V. E. Melchor, Dept. of Agric. and Chem., Va. State Univ., Petersburg, Va. 23803. We have kept 5 morphs of the Colorado potato beetle in our lab since we discovered them in 1979. Their first instars responded to chemicals differently. The  $LD_{50}$ 's of carbaryl were 22, 34, 50, 59, 68 ppm for morphs V, C, J, L, and B respectively. Malathion had  $LD_{50}$ 's: 87, 50, 55, 40, and 105 ppm to V, C, J, L and B insects. Chlorothalonil was less toxic to this insect, and it had  $LD_{50}$ 's: 1,500, 2,100, 1,400, 935 and 3,200 ppm to types V, C, J, L, and B. Morph C had the highest population of the five, therefore, this morph was selected for tests of combinations of these three pesticides at  $LD_{50}$ 's when carbaryl and chlorothalonil were applied together concentration of their mortality increased 20-40% or up to 90%. While chlorothalonil and malathion increased mortality up to 80%, carbaryl and malathion increased killing up to 100%, and all three together performed 100% kill. Squash and tomato seeds were grown in peat pots of soil mixture containing carbaryl, chlorthalonil and malathion at recommended rates, one tenth and a hundredth of the recommended. We found that carbaryl inhibited germination of both seeds most and malathion the next, however chlorothalonil seemed to enhance the germination.

THE STRUCTURE AND FUNCTION OF THE OVIPOSITOR OF HYLOTRUPES BAJULUS (L.)

(COLEOPTERA: CERAMBYCIDAE). J. T. Mares and W. H. Robinson, Dept. of Entomol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. The Old House Borer, Hylotrupes bajulus (L.) (Coleoptera: Cerambycidae) (OHB), is a serious pest of seasoned softwoods. Adult OHB females select cracks and crevices in the various softwoods, especially Pinus spp, for oviposition sites. Existing research shows that the female OHB uses her ovipositor to test the suitability of the substrate for oviposition. Examination by scanning electron and light microscopy indicates that the ovipositor consists of the modified abdominal segments VI-X. Various types of sensory receptors can be found on the ovipositor especially on the terminal segment and cerci. Mechanoreceptors are comprised of long tactile hairs and campaniform receptors. Chemoreceptors consist of multiple-dendrite hairs and pegs.

COMPARATIVE PERFORMANCE OF THREE COW TYPES WHEN MATED TO TWO KINDS OF CROSSBRED BULLS. T. J. Marlowe, Gretchen Kirsch\* and K. Nadarajah. Va Tech, Blacksburg 24061. Records on fertility, calf survival, and growth performance to weaning on 234 straightbred (SB), 487 single cross (2W) and 317 three-breed cross (3W) cow exposures at 3 locations to Angus (AA), Limousin x Shorthorn (L $\bar{S}$ ) and Maine-Anjou x Shorthorn (M $\bar{S}$ ) bulls were analyzed by least squares (LS) procedures. Crossbred cows weaned more kg of calf than SB cows when mated to the same bulls. Calf losses were greatest (16.6%) and weaning rate lowest (74.7%) for the 2W cows. Adj. 205d wts were lowest for SB cows (170 vs 193 and 190 kg). Cow rank, based on kg calf wn/cow exposed, was SB (132 kg), 2W (147 kg) and 3W (162 kg). Other differences were small and generally nonsignificant. Calves sired by M $\bar{S}$  bulls were superior to L $\bar{S}$  sired calves by 31 kg/cow due solely to higher weaning rate. AA sired calves were intermediate. Because AA bulls were used only on first calf heifers they had an advantage in conception rate but the major difference was in calf losses (1.1 vs 18.0 and 14.1%).

EFFECT OF MATING TYPE ON COW AND CALF PERFORMANCE. T. J. Marlowe and K. Nadarajah, Virginia Tech, Blacksburg 24061. Limousin x Shorthorn (L $\bar{S}$ ) and Maine Anjou x Shorthorn (M $\bar{S}$ ) bulls were mated to several F $_1$  cow types at 4 locations (loc) for 2 calf crops (1979, 1980). Cow types compared were Angus (A) and Hereford (H) straightbreds (PB). Crossbred types were AH, B Swiss x H (BH), Charolais x A (CA), CH, Holstein x A (FA), FH, Shorthorn x H (SH) and Simmental x H (SH). Because cow type differed among loc, data were analyzed within loc. Number of matings by loc were Bland (Bl) 340, Hanover (Ha) 260, Southampton (So) 293, and State Farm (SF) 558, with total matings of 621 to L $\bar{S}$  and 627 to M $\bar{S}$  bulls and 203 PB controls. Sire breed was signif only at So favoring M $\bar{S}$  by 23 kg/cow. Highly signif diff among cow type at all loc. All XB cows were superior (sup) to all PB cows at all loc except for Sm cows at Bl. FA and FH cows sup at all loc except at Bl where they tied with SH. Other XB cows were intermediate with Continental and dairy Xs generally above British Xs. CH and SH were similar in wn wt but CH lower in weaning rate and total wt weaned.

RELOCATION OF TWO IMPORTED THISTLE FEEDING INSECTS ALONG THE INTERSTATE HIGHWAY IN VIRGINIA. T. J. McAvoy\*, W. Mays and L. T. Kok, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Two thistle feeding weevils, Rhinocyllus conicus and Trichosirocalus horridus, were imported from Southern Europe and released in Western Virginia from 1969-76 as biological control agents of Carduus spp. thistles. T. horridus and R. conicus are now established in 7 and 22 counties west of the Blue Ridge, respectively. In June of 1981 and 1982, releases of 500 R. conicus and 125-150 T. horridus were made at 21 sites from Charlottesville north to Loudon County and at 6 sites from Winchester south to Lexington along the primary highways. In 1982, R. conicus was observed at all 27 sites except for one site in Greene County. Establishment of T. horridus was observed at 2 sites in Albermarle County and 1 site in Fauquier County.

DAMAGE POTENTIAL OF CEREAL LEAF BEETLES IN VIRGINIA SMALL GRAINS. Robert M. McPherson, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Cereal leaf beetle, Oulema melanopus (L.), population densities were evaluated in controlled field plots in soft red winter wheat, winter barley, spring oats, and field corn during 1980-82. Populations of 1.3-1.6 beetles/culm significantly reduced wheat yields 5.8 bu/a (17.2%). Populations of 0.6/culm reduced barley yields 2.3 bu/a below the treated plots. Densities of 7.7-11.6/culm reduced oat yields an average of 29.5 bu/a (60.9%). Field corn yields were not significantly affected by beetle feeding even though defoliation approached 40-50% during late June. More beetle eggs were observed in oats treated in early spring with 1.12 kg ai/ha of disulfoton to control aphids than in untreated plots. Similar treatments in wheat and barley did not influence egg numbers.

EFFECTS OF CULTIVAR, ROW PATTERN AND SEEDING RATES ON THE YIELD, VALUE AND GRADE OF VIRGINIA TYPE PEANUTS. R. Walton Mazingo and T. A. Coffelt\*, Tidewater Res. and Continuing Education Ctr., VPI&SU and USDA ARS, Suffolk, VA 23437. The effects of cultivars, row patterns and seeding rates on the yield, value and grade of virginia-type peanuts were studied for four years at the Tidewater Research and Continuing Education Center in Suffolk, Virginia. The cultivars Florigiant and Virginia 81 Bunch were seeded at the rate of 58,080 and 87,120 seed per acre in a single and double row pattern. Virginia 81 Bunch had a higher percentage of extra large kernels, sound mature kernels, total meat and value per acre than did Florigiant. No differences were found for yield between the cultivars; however, Florigiant produced a higher percentage of fancy size pods. The only effect of row pattern was on the percentage of fancy pods and total meat where the single row pattern was higher than the double row pattern. Seeding rates had no effects on the grades. However, significantly higher yield and value per acre was recorded for the higher seeding rate.

COMPARATIVE GROWTH PATTERN OF COWS Sired BY BRITISH AND CONTINENTAL BEEF AND AMERICAN DAIRY BULLS AND OUT OF HEREFORD DAMS. K. Nadarajah, T. J. Marlowe and D. R. Notter, Virginia Tech, Blacksburg 24061. Growth patterns and condition (cond) scores of 92 Herefords (H) and 299 crossbred (XB) female progeny of H dams sired by two British (Br) (Angus, A, and Shorthorn, S), two Continental (Cont) (Charolais, C, and Simmental, S) and two American dairy (Da) breed (Brown Swiss, B, and Holstein, F) bulls were compared from birth to maturity (M). Breed types differed signif. Both straightbred (SB) H and Br crosses (BrX) were lighter than Cont and Da Xs. BrX and SB H diff only slightly. Among XB, SH wt most (34 kg) at birth and AH wt least (30 kg). Wn wt of Cont X were 2.6 kg more than BrX and 1.7 kg more than DaX. At 30 mo Cont and Da Xs wt 41 and 23 kg more than BrX. DaX were intermediate. Breed type means at each age were used to fit Brody and Richards growth models. Asymptotic wts of ContX were highest, followed by DaX. BrX and HH avg less at M (487 kg). CH cows M more slowly but grew to heavier M wt (582 kg) than SH cows (563 kg). Among the BrX, SH reached M wt well before AHXs. DaXs had almost ident M wt (538 kg) that were intermediate to Br and Cont Xs. Adj wt for cond did not change rank of breed types but reduced phenotypic diff among breed type slightly.

LEAFSPOT BACTERIUM TRANSMITTED BY *Liriomyza trifolii*. Sidney L. Poe, Dept. of Entomol., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. Number of bacterial leaf spots (BLS) (*Pseudomonas*) on leaves of *Chrysanthemum* stock plants was positively correlated to the number of foliage damage sites caused by the leafminer, *Liriomyza trifolii*. Damage sites by caterpillars also provided a court through which the bacterium could penetrate plant tissues. Insecticide treatments, fertilizer source and cultivar influenced the number of mines and stipples of leafminer and thus BLS. Miner damage was greater on plants fed  $\text{NH}_4\text{NO}_3$  than on plants fed  $\text{CaNO}_3$ . Iceberg, Indianapolis White, Improved Rivalry and Nob Hill showed decreasing levels of leafminer attack. An increase by 10 in the number of leafminer and caterpillar damage sites, resulted in a corresponding increase of six and seven BLS respectively. Bacterial leaf spot appears to require insect injury for entry into the plant.

EFFECT OF METHODOLOGIES ON THE COMPOSITION AND PROPERTIES OF DIETARY FIBER FROM WINGED BEANS. G. Ravindran & J. K. Palmer, Dept. of Food Science, VPI&SU, Blacksburg, Va. 24061. Winged beans (WB) contain about 25% dietary fiber (DF), defined as non-starch polysaccharides, and are exceptionally high (Ca 35%) in protein. Dietary fiber has been extracted from winged bean by 5 methods designed for use on the more typical high-starch, low-protein foods. The DF of WB is virtually all "insoluble" fiber, soluble fractions only being obtained when extractions is at elevated temperatures. Galactans predominate in all cases, but the DF also contains substantial glucose (as cellulose), arabinose, xylose, uronic acid, protein, lignin and ash. Considerable differences in the composition and properties of DF fractions resulted from use of the different methods.

**MAXIMUM YIELD RESEARCH WITH SOYBEANS.** Preston H. Reid, D. L. Hallock, Tidewater Research and Continuing Education Center, Suffolk, VA 23437, F. S. Wright\*, USDA, ARS, Suffolk, VA 23437 & Norris Powell\*, Dept. of Agron., VPI & SU, Blacksburg, VA 24061. Multidiscipline research was conducted to determine maximum returns from economic inputs. Ring Around 604 cultivar yielded 6 bu/A more than Coker 156. Reducing row width from 30 inches to 10 inches increased yields from 46.5 to 61.4 bu/A. Yields increased with plant population to approximately 70,000 plants per acre. No response was obtained by maintaining the soil moisture at 50% plus of the soil available water. In 1981 there was a decrease from irrigation despite the dry weather. Maximum yields of 68.5 bu/A were obtained with Ring Around 604 cultivar grown in 10 inch rows at population of 102,000 plants per acre. Lodging was severe in all plots and may have limited yields. Soybeans planted in killed small grain yielded 64.0 bu/A compared to 58.7 bu/A for those planted in a conventional seed bed. Erosion was less severe in the no-till plots.

**ROW WIDTH, PLANT POPULATION STUDIES WITH SOYBEANS.** Preston H. Reid, David A. Morris\*, John W. Murphy, Jr.\* and John C. Smith, Tidewater Research and Continuing Education Center, VPI & SU, Suffolk, VA 23437. Soybeans were planted at seeding rates from 33,000 to 300,000 seed per acre and at row widths from 10 inches to 36 inches apart. Significant yield increases attained when row widths were reduced to 20 or 24 inches from 30 to 36 inches. Responses from further reductions in row width beyond 20" were less consistent but did occur on occasion.\* Lodging was increased by both very low and very high plant populations. Yields were not increased by plant population greater than 100,000 but height of first pod bearing node and plant height were increased up to 300,000 plants per acre. Summary of all tests indicates that optimum row width for soybean production is between 10 and 20 inches and optimum plant populations are 100,000 to 150,000 plants per acre.

**COMMON STALK BORER, PAPAPEMA NEBRIS (GUENEE) (LEPIDOPTERA : NOCTUIDAE), CONTROL IN FIELD CORN, ZEA MAYS (LINNAEUS), WITH VARIOUS INSECTICIDES AND A CULTURAL METHOD.** James E. Roberts, Sr. and Michael Saluta\*, Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

At-planting and rescue treatments and a semi-conventional cultural method were applied in 1982 to no-till field corn in Blacksburg, VA. The test site was arranged in a randomized complete block design, measuring 4 rows (38 in. spacing) X 50 ft. X 4 replicates. The preplanting cultural treatment consisted of mowing the rye cover crop followed by tillage to a depth of 3-4 in. The granular treatments (Lorsban™ 15G) were applied at-planting, May 17. The foliar rescue treatments (Ammo® 2.5 EC, Dyfonate® 4E, Imidan® 50W, and Pounce® 3.2 EC) were applied Jun. 4 to the 3 leaf stage corn with a compressed air sprayer delivering 20 gal./A. Stalk borer damage was evaluated for all treatments Jun. 13 by using a random visual plant damage rating scale.

A moderate to heavy stalk borer infestation prevailed throughout the test area at the time of rescue treatments. Analysis indicated that feeding damage in the untreated control was significantly greater than the treated plots ( $P < 0.05$ ), however yield differences were found to be nonsignificant ( $P > 0.05$ ).

CONTROL OF THE HOG LOUSE, HAEMATOPINUS SUIS (LINNAEUS) (ANOPLURA : HAEMATOPINADAE), ON BROOD SOWS, SUS SCROFA (LINNAEUS), WITH ECTRIN™ 8% EAR TAGS. James E. Roberts, Sr. and Michael Saluta\*, Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

Four tests were conducted in Virginia from Dec. 1981 through Feb. 1982 for control of hog lice on brood sows with Ectrin™ 8% ear tags. All treated animals received 2 ear tags, one in each ear. Efficacy of treatments was ascertained by recording in weekly intervals the number of lice present on each animal. All animals were either confined individually in farrowing houses or pastured in an uncontrolled environment. A comparative control group was used in each test.

In all tests hog lice populations were significantly reduced after 2-3 weeks. Total lice control was achieved by the 4th week in all but one test. Where tests were conducted in farrowing houses, it was noted that the treated sows' pigs were free of lice. All untreated control animals continued to be infested. A total of 4 tags were lost from 3 animals. No other adverse reactions to the ear tags were noted.

EVALUATION OF A SYNERGIST WHEN ADDED TO SYNTHETIC PYRETHROIDS FOR CONTROL OF THE HOUSE FLY, MUSCA DOMESTICA (LINNAEUS) (DIPTERA : MUSCIDAE), IN DAIRY PREMISES. James E. Roberts, Sr. and Michael Saluta\* Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

Prentox® PBO 8™ (91.3% Piperonyl Butoxide Technical) was applied as a 5:1 tank mix with one half recommended rates of Ectiban® 5.7% EC and Ectrin™ 10% WDL, Jul. through Sep., 1982, to dairy premises in Montgomery Co., VA. Standard rates of both insecticides were also applied to dairies for comparative efficacy. Treatments were applied at separate dairies with a high pressure sprayer (100 psi). Weekly fly counts were made at all locations, using two methods to evaluate populations. Enumeration of flies lighting on a 'Scudder grill' after 1 min. and an Aeroxon® 'Fly Catchers' sticky tape after 45 min. were recorded at specific sites in a premise. Data were averaged on each day in each treatment.

The posttreatment analyses indicated that generally there were no significant differences ( $P>0.05$ ) among those treatments with PBO 8 and those without. In terms of % reduction, the Ectiban & PBO 8 treatment resulted in the most effective control (sticky tape, >59% and Scudder grill, >83%).

FACE FLY, MUSCA AUTUMNALIS DE GEER, AND HORN FLY, HAEMATOBIA IRRITANS (LINNAEUS) (DIPTERA : MUSCIDAE), CONTROL ON BEEF CATTLE, BOS TAURUS (LINNAEUS). James E. Roberts, Sr. and Michael Saluta\*, Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

Several insecticides and application methods were evaluated Jun. through Sep., 1982, on 5 separate herds of beef cattle located in Montgomery Co. and Blacksburg, VA. Treatments consisted of forced usage backrubbers and face-rubbers charged with Ravap® EC and Ectiban® 5.7% EC, Ectrin™ 8% ear tags (2 per animal), and a Dustacator® charged with Ectiban® 0.25% dust. All herds were within ca. 2 miles of each other. Weekly fly counts were made on 10 animals per herd for the duration of the fly season. Comparative efficacy was based on an untreated control herd.

The Ectiban EC treatment was the most effective in controlling face flies (>70%). The Ectrin ear tags provided good control of face flies for the first 7 weeks (>63%), but their effectiveness varied for the remaining weeks. The Ravap EC and Ectiban dust treatments resulted in poor control of face flies. All treatments provided excellent control of horn flies.

TRUE ARMYWORM, PSEUDALETIA UNIPUNCTA (HAWORTH) (LEPIDOPTERA : NOCTUIDAE), CONTROL IN FIELD CORN, ZEA MAYS (LINNAEUS), WITH POUNCE® 3.2 EC AND AMMO® 2.5 EC. James E. Roberts, Sr. and Michael Saluta\*, Dept. of Entomology, VPI&SU, Blacksburg, VA 24061.

Pounce® 3.2 EC and Ammo® 2.5 EC were applied as rescue treatments to no-till seedling field corn in Montgomery Co., VA. The test site was arranged in a randomized complete block design, measuring 4 rows (36 in. spacing) X 50 ft. X 4 replicates. The treatments were applied Jun. 15, 1982, with a compressed air sprayer delivering 20 gal./A. Pretreatment data were recorded Jun. 15. Damage levels were calculated as the mean percentage of plants per treatment showing evidence of true armyworm feeding. Posttreatment data were recorded Jun. 18, 21, and 24 from the identical plants in each plot and averaged.

True armyworm feeding damage was moderate to heavy throughout the test area at the time of treatment. Posttreatment analysis indicated a significantly greater mean damage increase of 23% in the untreated control ( $P < 0.05$ ). The rescue treatments were effective and did not vary significantly in curtailing further armyworm feeding (<5% mean damage increase).

FEEDING PREFERENCE OF HAWTHORN LACE BUG. P. B. Schultz. VA Truck & Ornamentals Res. Stn., Va. Beach, VA 23455. Five species/cultivars each of Cotoneaster and Pyracantha were caged in 1981 and 1982 with adults of the hawthorn lace bug, Corythucha cydoniae (Fitch), to evaluate feeding preference. Both terminal and non-terminal cuttings were used in laboratory studies while Cotoneaster were evaluated in outdoor cage studies in 1982. C. horizontalis and P. atalantiodes 'Aurea' were least preferred while C. dammeri 'Royal Beauty' and P. koidzumii 'Ingleside Crimson' were the most preferred cultivars. There was no difference between terminal and non-terminal cuttings. C. horizontalis developed lower lace bug numbers than the other species/cultivars in the field study. In a related laboratory study using leaf disks, feeding preference between Cotoneaster, Crataegus, Pyracantha and Sorbus, hawthorn lace bug preferred Sorbus regardless of prior feeding.

1982 TILLAGE FIELD TESTS IN SOYBEANS. Easley S. Smith\*, David H. Vaughan, & John V. Perumpral\*, Dept. of Agri. Engr., Va. Tech, Blacksburg, VA 24061 & Preston H. Reid, Tidewater Res. & Continuing Education Ctr., Holland Station, Suffolk, VA 23437. Soybean response to various tillage practices was evaluated when double-cropping in a straw mulch following wheat harvest. Under-row ripping to 6, 10, and 14-inch depths and no-till planting treatments were replicated at three locations in different soils. A once-over operation with a modified three-row toolbar mounted ripper-planter was used. Fuel requirements increased considerably at the deeper tillage depths. Seed germination and stand counts were slightly higher in the deep tilled plots. Harvest yields were similar for all treatments in Turbeville and Woodstown fine sandy loam soils of Goochland and Middlesex Counties, respectively. Increases of 2-7 bu. per acre were noted in deep ripped as compared to no ripped plots in Emporia loamy sand soil of Greensville County. Disking prior to ripping and planting gave no desirable yield response. (Supported by funds from the Va. Agri. Fndn. and Va. Soybean Commission.)

SOUTHERN CORN ROOTWORM CONTROL IN PEANUTS IN SIX SOUTHEAST VIRGINIA COUNTIES. J. C. Smith, Tidewater Res. Ctr., VPI&SU, Suffolk, VA 23437. Research/demonstration plots in six southeastern Virginia counties were established in July 1982 for control of the southern corn rootworm, Diabrotica undecimpunctata howardi Barber. Efficacy ratings from best to worst were: Furadan 15G @ 2.0 lb ai/acre, Dyfonate 10G @ 2.0 lb ai/acre, Thimet 15G @ 2.0 lb ai/acre, Furadan 4F @ 2.0 lb ai/acre, Mocap 10G @ 2.5 lb ai/acre, Lorsban 4E @ 2.0 lb ai/acre, Untreated Control. Average % injured pods ranged from 3.4 to 21.2. Yields of peanuts from treatments ranged from 3875 (Untreated Control) to 2879 lb/acre (Furadan 15G). The order of descending yields was: Untreated Control, Lorsban 4E, Furadan 4F, Lorsban 15G, Thimet 20G, Mocap 10G, Dyfonate 10G, Furadan 15G. Values (grade X yield) were in the same sequence as yield. Yield and value parameters did not parallel efficacy results.



A MICROELECTROPHORETIC TECHNIQUE FOR DETERMINING SPECIES AND POPULATION AFFILIATIONS OF SINGLE INSECT EGGS. M.W. Varn, D.G. Pfeiffer, and F.W. Ravlin. Dept. of Entomol. VPISU, Blacksburg, Virginia 24061. An SDS-PAGE (sodium dodecyl sulfate microslab linear gradient polyacrylamide gel electrophoresis) technique adapted from Matsudaira and Burgess (1978) was used to separate the proteins of single eggs of several species of apple aphids and several populations of gypsy moths. This was accomplished by using a .45-.75 mm gel followed by either a coloring (Sammons et al. 1981) or a non-coloring silver stain (Merril et al. 1982). This technique allows the identification of pest aphid species previously indistinguishable prior to egg hatch; and thus permits pest managers to anticipate control measures. The technique also allows the mapping of patterns of genetic variability of gypsy moth populations of various densities.

BIOLOGY OF MEGACERUS DISCOIDEUS (SAY) ON HEDGE BINDWEED AND ITS SYNCHRONIZATION WITH THE HOST PHENOLOGY IN SOUTHWESTERN VIRGINIA. R. Wang\* and L. T. Kok, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Megacerus discoideus (Say) (Coleoptera: Bruchidae), a seed feeder, is considered one of the most promising biocontrol agents of the hedge bindweed, Convolvulus sepium L. Studies of this bruchid conducted in southwestern Virginia in 1982 revealed good synchronization between the life cycle of the insect and the phenology of hedge bindweed. M. discoideus has 4 larval instars and one generation a year. It overwinters in the fourth instar. The adults emerged from late June to late July. Oviposition peaked during formation of the bindweed seedpods. The larvae burrowed into the young seedpods within 24 hours after eclosion, consuming about 40-50% of the seed material by the time the host plant becomes senescent in early Sept. Larvae diapaused in September, and fed on the remaining seed material after diapause in spring. Although several larvae were found within a seed, only one could complete its life cycle in each seed. Cannibalism was most common among 2nd instars.

HORMONAL REGULATION OF PROGESTERONE SECRETION BY THE OVINE PLACENTA. S.M. Zirkle, S.J. Philpott and W.E. Beal, Dept. of Animal Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. This experiment was designed to determine the factors controlling placental synthesis of progesterone (P4). On day (d) 65 of gestation, ewes in Group I were fitted with an implant containing P4 (N=4) or a synthetic P4 (N=8). Each ewe was ovariectomized (OVX) on d 75 and implants were removed on d 120. Eight ewes were assigned as either intact or OVX controls. Blood samples were collected throughout gestation with frequent sampling on d 65-85 and d 119-125. Ten ewes in Group II were OVX on d 75 and were either injected with saline or 1000 I.U. of human chorionic gonadotrophin (HCG) on d 80 and 115. Group II ewes were intensively bled pre- and post-injection of HCG. Concentrations of P4 were determined by radioimmunoassay. Plasma P4 in intact ewes averaged 3 ng/ml on d 65-85 with an increase to 8 ng/ml from d 90-105. Between 105-115 the P4 levels in intact ewes increased to 15 ng/ml. Plasma P4 in OVX ewes implanted with P4 decreased to <2 ng/ml post-OVX, however, the subsequent temporal profile of P4 in the plasma was similar to that of control ewes. Ewes injected with HCG did not exhibit an increase in the plasma concentration of P4 over that of control ewes. Neither negative feedback nor gonadotrophin administration affected ovine placental P4 secretion.

## Astronomy, Mathematics, and Physics Section

THE DESIGN, CONSTRUCTION, AND DIAGNOSTICS OF A  $N_2$  PUMPED OSCILLATOR-AMPLIFIER DYE LASER FOR VISIBLE AND U.V. SPECTROSCOPY. Aron Bacs \* and G.E. Copeland, Dept. of Physics, Old Dominion University, Norfolk, Va. 23508. Details for the construction of a grazing incidence pulsed oscillator-amplifier dye laser are presented. It is constructed on an optical breadboard for simplicity. The major components of oscillator and amplifier are kept to a minimum, and thus easy to align. A 337.1 nm, 300 KW beam from a  $N_2$  laser is beamsplit to pump directly the oscillator and time delayed to pump the amplifier. The dye laser produces a pulsed output ( $\sim 12$  nsec) from 570 to 600 nm with a line width of 0.002 nm and power up to 50 KW using R6G in ethanol. A novel scheme for reducing amplifier superradiant feedback into the oscillator is described. Tuning is accomplished via a Z-80 microcomputer system controlling a stepping motor that turns the tuning mirror. The dye laser system has been used to investigate the opto-galvanic spectrum of neon which can be used for calibration. (Partially supported by NASA grants NAG-1-1 and NCC1-32)

MAGNETOSPHERIC ION EROSION OF THE ICY SATELLITES OF SATURN.

Lynn A. Barton, Dept. of Nuclear Engineering and Engineering Physics, Univ. of VA., Thornton Hall, Charlottesville, VA. 22901. The five inner satellites of Saturn are known to be covered with water ice. Data from Pioneer and Voyager indicate that these icy surfaces are exposed to bombardment by energetic ions. In addition, the presence of heavy ions in the vicinity of these satellites implies the existence of a cloud of heavy neutral molecules, presumably water. In this paper I show that sputtering of ice by the plasma ions is a source of heavy ions in the magnetosphere.

A LASER/OPTICAL FIBER ROTOR TIMING SYSTEM, Bruce E. Bernard,\* Dept. of Physics, University of Virginia, Charlottesville, VA 22901. A precision timing system which utilizes an optical fiber to guide laser light to a reflecting surface on a spinning rotor and trigger an optical sensor which sends a signal to a computerized data acquisition system is described. The timing system is used to measure the period of rotation of a magnetically suspended rotor spinning at  $\sim 1$  Hz which is part of a gravitational experiment. The effects of noise and non-rotational motion of the rotor which limit the resolution of the period measurements are discussed. (This research is supported by NSF Grant PHY80-07948 and NBS Grant G8-9025).

INTRODUCING LOG-LOG PLOTS VIA EXPERIMENT. D. Rae Carpenter, Jr., Dept. of Physics, Va. Military Inst., Lexington, VA 24450. Data taken on AC voltage vs current in incandescent lamps of power ratings from 15 to 200 watts will produce a straight line when plotted as  $\ln V$  vs  $\ln I$ . This shows the mathematical relationship to be  $V = V_0 I^m$ . Values of  $V_0$  depend markedly upon the power rating. The slope of the plots,  $m$ , is reasonably constant over a wide range of power ratings. There are some variations among bulbs produced by different manufacturers.

The experiment involves simple apparatus and the data can be taken quickly enough to warrant measuring several bulbs so as to produce a family of curves. Discussion of the meaning of "intercept" on a log-log plot may be necessary, i.e., the value of  $V$  when  $I = 1$ .

SOFT X-RAY EMISSION STUDIES OF SILICON MATERIALS. R. D. Carson\* and S.E. Schnatterly, Department of Physics, University of Virginia, Charlottesville, VA 22901. The silicon  $L_{23}$  x-ray emission spectrum has been used to study the valence band density of states for several silicon materials. The amorphous silicon spectrum shows broadened features but with a steeper high energy tail compared to that of crystalline silicon. Samples of amorphous silicon, heavily doped crystalline silicon and silicon nitride show a feature near the top of the valence band which is believed to be from conduction band states. This feature is particularly prominent in silicon nitride which has a 4 volt band gap and emission from states which appear to be in the band gap is evident. The spectra also show dependence on the energy of the electron beam used to excite the x-rays. These results will be presented and discussed.

MOVING MATERIAL INTO SPACE WITHOUT ROCKETS. Raymond S. Cheng,\* and James S. Trefil,\* Dept. of Physics, Univ. of Va., Charlottesville, Va, 22901. Early steps in the humanization of space include transporting large amounts of metal and other building materials to orbital altitudes. As in other applications, conventional rockets would be burdened with carrying their fuel as they ascend. This inherent inefficiency is avoided through the use of electromagnetic launchers. Fired from these ground-based devices, the payloads drift to desired heights where they are intercepted. Energy profiles and trajectories of launched bodies are computed using successively more complex models of the earth and atmosphere. The results indicate that energy savings are significant when launchers are used.

NUCLEAR WAR - - IS IT SURVIVABLE? Robert Ehrlich, Dept. of Physics, George Mason Univ., Fairfax, VA 22030. Any answer to this question clearly depends greatly on the definition of "survivable". However, within very wide limits imposed by the many uncertainties, certain projections based on scientific facts can be made. It is important to try to be objective on this question, since there are often tendencies to either overstate or understate the probable consequences of a nuclear war to support a particular political position. The material presented in this talk is part of an interdisciplinary course on nuclear war which I have been offering at GMU for the past two years.

AIR TABLE EXPERIMENTS WITHOUT AN AIR TABLE. Robert Ehrlich, Dept. of Physics, George Mason Univ., Fairfax, VA 22030. A new method has been developed for conducting a wide range of mechanics experiments suitable for introductory physics courses. The method utilizes a new device which can be used for many of the same kinds of experiments that can now be done on an air table. The simple construction of the device will be described, and its advantages and disadvantages compared to the air table will be discussed. Results for ten different experiments including: uniformly accelerated motion, collisions, Newton's Second Law, the pendulum, simple harmonic motion, conservation of angular motion, and Lissajous figures will be displayed and discussed.

SOME QUANTITATIVE ASPECTS OF EMISSION COMPUTED TOMOGRAPHY OF RADIOISOTOPES. Zia R. Hashmi\*, 9256 Ashland Woods Lane, Lorton, Va. 22079. Computerized tomography has become an important tool in medical radiography for displaying the internal structural patterns of a complex object. Of particular interest is the technique of single photon emission computed tomography<sup>1</sup> because of its value in nuclear medicine wherein viable physiologic radiopharmaceutical tracers are used for quantifiable radioactive distributions and their emissions. An important parameter involved in such techniques is the depth resolution. The concept of specificity was introduced earlier<sup>2</sup> for quantification of depth resolution of tomographic devices. The application of such quantitative concepts to single photon emission computed tomography is discussed in this paper.

1. "Emission Computed Tomography: The Single Photon Approach", Bureau of Radiological Health, HHS Publ. FDA81-8177 (1981). 2. G. Muehlethner & Z. Hashmi, Phys. Med. Biol. 17, 251 (1972).

ON THE COULOMB SCATTERING PROBLEM IN THE PRESENCE OF AN INTENSE LASER FIELD. J.C. Huang\*, Phys. Dept., Univ. of Missouri, Columbia, MO 65211, and W. Majewski\*, Phys. Dept., Univ. of Maryland, College Park, MD 20742. A comparison to the lowest order in an intensity dependent dimensionless coupling constant is made between the semiclassical Volkov and QED approaches to the Coulomb scattering problem in the presence of a high intensity external E & M field. In the nonrelativistic infrared limit, the elastic, one photon emission and absorption cross sections are essentially the same. However, the relativistic comparison indicates differences which are more pronounced.

EXCITATION SPECTRUM OF A ONE-DIMENSIONAL ANTIFERROMAGNET AT FINITE MAGNETIZATION. Michael D. Johnson\*, Dept. of Physics, U.Va., Charlottesville, VA 22901. In developing a quantum theory of ferro- and antiferromagnetism, the intractability of the three-dimensional theory spurred the study of simplified one-dimensional models. More recently, these idealized systems have become interesting in their own right, as a result of two developments: the manufacture of quasi-one-dimensional magnetic materials, and the discovery that the one-dimensional magnetic model lies in a larger class of exactly soluble one-dimensional many-body systems. The state of a system is described quantum mechanically as a set of allowed energy levels; at low temperatures, only the lowest energy states are of physical interest. We have computed these elementary excitations (at zero temperature) for an anisotropic (xxz) one-dimensional antiferromagnet in the presence of an external magnetic field.

EPR SATURATION RECOVERY IN MYOGLOBIN. Paul D. Levin\* and A.S. Brill\*, Biophysics Program and Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901. Between 2K and 4K the recovery from power saturation of the EPR signal of myoglobin is mostly due to the two phonon Orbach process with some contribution from the single phonon direct process. The recovery curve is not a single exponential function but arises from a distribution of single exponential recovery signals based on a distribution of characteristic relaxation times,  $\tau_1$ . The experimental recovery curve may be fitted to a single exponential function which provides an effective relaxation time,  $T_1$ , the temperature dependence of which can be analyzed in terms of a four-level model of the heme iron based on distributions in state energies. Experimental and simulated data have been compared by means of a Marquardt non-linear least squares fitting routine, and, currently, a linear polynomial expansion in temperature. The energy fluctuations obtained in this way are in agreement with those determined from the analysis of independent measurements.

ON A NEW PARITY-VIOLATING EFFECT IN ATOMS. Walerian Majewski\*, Phys. Dept., Univ. of Maryland, College Park, MD 20742. We show that the electric part of the nuclear current produces a short-range magnetic field inside the nucleus. This field is usually either neglected, or is considered to be vanishing automatically. It can be parametrized in terms of nuclear static transverse electric multipole moments  $E_{\lambda}$ . The moments with even  $\lambda$  are forbidden by T-invariance, and those with odd  $\lambda$  are forbidden by P-invariance. The influence of the nuclear parity impurity on the parity impurity of atomic levels is estimated.

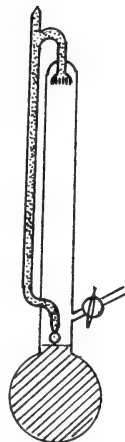
SUPERCONDUCTIVITY OF EXTREMELY SMALL TUNGSTEN CARBIDE PARTICLES. P.M. Miller, M.T. Lough and B.S. Deaver, Jr., Dept. of Physics, Univ. of Va., Charlottesville, VA, 22901. The superconductivity of cubic WC particles of mean diameters 10, 6 and 3 nm is being studied by measurements of the magnetization as a function of temperature and magnetic field to search for possible size effects. Measurements are being made with a SQUID susceptometer and with an ac technique on powder samples with connectivity among the particles and on particles dispersed in an insulating matrix. Fits to theoretical curves provide values for the transition temperature  $T_c$ , critical field and gap parameter. For all the samples  $T_c \approx 6.5$  K.

A FORMULATION OF RIGID-BODY ROTATIONAL DYNAMICS BASED ON EULER PARAMETERS AND CONJUGATE GENERALIZED ANGULAR MOMENTA. Harold S. Morton Jr., Dept. of Mech. and Aero. Engineering, University of Virginia, Charlottesville, Va. 22901. The orientation of an arbitrary rigid body is specified in terms of a set of four Euler parameters. A corresponding set of generalized angular momentum variables is derived and then used to replace the usual angular velocity vector in specifying the time-rate-of-change of orientation relative to inertial space. This leads naturally to a formulation of rigid-body rotational dynamics in terms of a system of eight first-order coupled differential equations involving the four Euler parameters and the four conjugate angular momenta. The equations are expressed in matrix form and exhibit a remarkable symmetry, which represents the key result. Euler's equations are used in the derivation, and the results are, of course, consistent with Hamilton's equations.

THE PHYSICS OF A RELATIVISTIC OSCILLATOR. W. Barlow Newbolt, Dept. of Physics, Washington and Lee University, Lexington, Va., 24450. Because of its usefulness in teaching the special theory of relativity, the properties of a relativistic oscillator are described in this paper. Two features of the oscillator are emphasized: its mechanics and its usefulness as a device to measure time intervals.

INTERACTION OF NEPTUNIUM-239 (X) WITH DOG SERUM IN VITRO. David A. Petersen, Dept. of Chemistry and Geology, Mary Washington Col., Fredericksburg, Va. 22401, Dr. R. A. Guilmette and Dr. M. A. Medinsky, Inhalation Toxicology Research Institute (ITRI), Albuquerque, N. M. Serum Protein Binding or association of Np-239 (pentavalent state) was clearly indicated by gamma and U.V. spectroscopy of various Np incubated serum protein samples. Protein bound Neptunium Fractions were separated by TCA precipitation, dialysis, ultrafiltration, and gel chromatography methods. Ratios of activity present in the protein bound fractions to non-bound fractions were used for this determination. (This work was completed at the ITRI in Albuquerque, N. M. under an A.W.U. grant.)

A SENSITIVE TEST OF THE SECOND LAW OF THERMODYNAMICS. C. B. Satterthwaite, Dept. of Physics, Va. Commonwealth Univ., Richmond, Va. 23284. The accompanying sketch is a prototype of a familiar perpetual motion machine of the second kind. The column of water in the reentrant tube, which is filled with tiny glass beads, is held up by surface tension. The water surfaces in the pores of the sintered glass disc at the top are, therefore, concave and have a lower vapor pressure than a flat surface. Naively, one might think that water would evaporate from the flat surface and condense in the pores causing a continuous flow of water. This complete conversion of heat energy to mechanical energy, of course, violates the second law of thermodynamics and can be shown not to work if one considers the gradient of vapor density in a gravitational field. It is, nonetheless, a sensitive test of the second law.



$\text{Li}_{11}\text{H}$  AND  $\text{Li}_{15}\text{H}$  CLUSTER MODELS OF MUON PROBES IN BCC METALS. D.D. Shillady and P. Jena, Depts. of Chem. and Physics, Virginia Commonwealth Univ., Richmond, Va. 23284. Hartree-Fock-Roothaan self-consistent-field calculations have been carried out for  $\text{Li}_{11}\text{H}$  and  $\text{Li}_{15}\text{H}$  using a (3G1S/1G2S/1G2P) basis for Li and (4G1S/2G2S/1G2P) for H as lobe-mimics of spherical harmonics. The energy difference between  $0_{\text{h}}$  and the favored  $T_{\text{d}}$  sites for H depend on the size of the cluster studied; in  $\text{Li}_{15}\text{H}$  this difference was found to be 0.136 eV. The barrier to diffusion along the (1,1,1) direction is prohibitive relative to  $0_{\text{h}}\text{-}T_{\text{d}}$  hopping. In a vacancy model ( $\text{Li}_{15}\text{H}$ ) H moves away from the vacancy and  $T_{\text{d}}$  sites are still lowest in energy, but the  $0_{\text{h}}\text{-}T_{\text{d}}$  barrier is less, allowing enhanced mobility around the vacancy. In the chosen basis a symmetric  $\text{Li}_{14}$  vacancy cluster contracted 11.4% in spite of the fact that the same basis predicts an 8.0% larger lattice constant than experiment (3.772Å calc. vs. 3.491Å exp.). These results predict a local lattice contraction about a vacancy with increased H mobility around the relatively repulsive vacancy site.

CHARACTERIZATION OF  $\text{CaF}_2$  FILMS DEPOSITED ON SINGLE CRYSTAL GE SURFACES. BILLY W. SLOOPE, Dept. of Physics, Va. Commonwealth Univ., Richmond, Va. 23284.  $\text{CaF}_2$  films were deposited by vacuum evaporation onto (100), (110), (111), and (112) Ge surfaces at various deposition temperatures and rates and to various thicknesses. Structure of the films was predominantly polycrystalline with an increasing (111) texture at deposition temperatures above 330°C. Continuity, grain size, and index of refraction also showed dependence on deposition temperature. Current-voltage measurements were made by depositing a small Ag electrode on top the  $\text{CaF}_2$  film. The I-V characteristics were generally non-symmetrical with respect to current direction, mostly non-linear, yielding no single power relationship, and at higher currents exhibited time variations in voltage. These characterizations will be summarized and some potential future directions of research discussed.

A RADIATIVE TRANSFER MODEL FOR REMOTE SENSING OF LASER INDUCED FLUORESCENCE IN STRATIFIED MEDIA. D. D. Venable, A. R. Punjabi\*, Dept. of Physics and Engineering Studies, Hampton Institute, Hampton, Va. 23668. A semi-analytic Monte Carlo radiative transfer model (SALMON) for oceanographic lidar systems has been applied to inhomogeneous media. The values of the ratio of the fluorescent wavelength signal ( $H_F$ ) to the Raman wavelength signal ( $H_R$ ) are determined for ambient chlorophyll concentrations ranging from 0.01  $\mu\text{g}/\%$  to 20  $\mu\text{g}/\%$ . The concentrations vary linearly as a function of depth in the medium with gradients of  $\pm 1\%$  per meter to  $\pm 20\%$  per meter. Comparison of the ratio  $H_F/H_R$  for homogeneous (zero gradient) and inhomogeneous cases show significantly large deviations at low concentrations and high gradients. The deviations decrease as concentrations increase or as gradients decrease. In our model, the surface of the medium is flat and no lateral inhomogeneities are allowed. (Supported by the National Aeronautics and Space Administration)

X-RAY TOPOGRAPHY OF NEARLY PERFECT CRYSTALS USING A MONOLITHIC DIFFRACTION SOURCE. R. F. Zilhaver\* and W. C. Sauder, Dept. of Physics, Va. Military Inst., Lexington, VA 24450. A new method of x-ray reflection topography is proposed. The Berg-Barrett method, double crystal technique of Bonse and Kappler, and the mismatched crystal arrangement of Deslattes, Torgeson, Paretzkin and Horton are all compared with the ideal topographic experiment. It is shown that the use of a monolithic double crystal spectrometer (MDCS) to condition the x-ray beam could provide a closer approach to the ideal. The new technique will permit the examination of as much as one square centimeter of the surface of a high perfection crystal.

## Biology Section

A COMPARATIVE STUDY OF THE EFFECTS OF TEMPERATURE ON RATES OF DEVELOPMENT IN SEA URCHINS. W. Bruce Adams\* and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. The rate of embryogenesis in sea urchins is temperature dependent. We examined the influence of temperature on development of Arbacia punctulata. Rates of development from fertilization through the pluteus larva stage were monitored at three temperatures (20°, 25°, and 30° C) in order to determine the exact relationship between these temperatures and rates of embryogenesis. Our studies indicated that at 25° C development proceeded faster than at either 20° C or 30° C. The rate of development at 30° C was somewhat faster than the rate of development at 20° C. The occurrence of a maximum rate of development at 25° C indicated that an optimum temperature for Arbacia punctulata embryogenesis may occur within the temperature range studied.

THE EFFECTS OF DEXATRIM DIET CAPSULES ON MICE. D.D. Alvis\*, A.F. Conway, and P.L. Dementi, Dept. of Biol., Randolph-Macon Col., Ashland VA 23005. Forty male white mice were grouped by age and then paired by weight. Five mice in each age group received 1.5 mg of phenylpropanolamine hydrochloride per kg of body weight in their water bottles; five received 3.0 mg/kg of body weight; and ten were controls. Body weight and water consumption were monitored daily for one month. At the end of this time period, the animals were sacrificed and their hearts, livers, and kidneys were removed and weighed. All animals gained weight during the experiment. A paired t-test revealed no significant differences in body weight gain or organ weights between experimental and control animals. Water intake by experimental mice was significantly greater than in controls.

THE ROLE OF THE ADRENAL CORTEX IN FAT METABOLISM OF THE MONGOLIAN GERBIL, (Meriones unguiculatus). Safia Baggia\* and Dr. Frank Leftwich, Dept. of Biology, Univ. of Richmond, Richmond, Va., 23173. Sixty four male Mongolian gerbils, Meriones unguiculatus were adrenalectomized and treated with daily injections of cortisol (.1mg) and aldosterone (50µg). Upon necropsy, depot fat was found to be significantly lower in the hormone treated groups. Blood free fatty acid was found to be significantly higher in the controls than in treated gerbils. Significant differences were also found in survival time and in the daily percent change in body weight of hormone treated groups.

PHENOBARBITAL TREATMENT DURING THE EARLY NEONATAL PERIOD RESULTS IN INCREASED HEPATIC P-450-DEPENDENT MONOOXYGENASE ACTIVITY IN ADULT MALE AND FEMALE SPRAGUE-DAWLEY RATS. Daniel M. Bagley\* and Johnnie R. Hayes\*, Dept. of Pharmacology and Toxicology, Medical College of Virginia, Richmond, VA 23298.

Phenobarbital (PB) was injected subcutaneously to neonatal male and female Sprague-Dawley rats once on each of the first five days after birth to determine the long term consequences of this treatment on the cytochrome P-450-dependent monooxygenase system. At 20 weeks of age there were no differences between treatment and control groups of either sex in liver weight as a percent of body weight and in mg. protein/g liver. However, both male and female PB treated groups showed significantly higher P-450 content, P-450 reductase activity, ethoxycoumarin-O-deethylase activity and 4-methylumbelliferone glucuronidation relative to controls.

These findings suggest that xenobiotics which typically have only transitory inductive effects in mature animals may cause permanent effects if the exposure occurs during early neonatal life.

ANDROLOGICAL EVALUATION OF MEN INFECTED WITH UREAPLASMA UREALYTICUM. William Ballard and Steve Ackerman, Andrology Laboratory, Dept. of Biol., Old Dominion Univ., Norfolk, Va. 23508. Several recent investigations have implicated reproductive tract infections of Ureaplasma urealyticum with abnormal semen parameters. In this study, semen samples from 134 males undergoing fertility evaluation from June 1 to October 31, 1982 were examined to determine if alterations in specific semen characteristics were associated with the presence or absence of U. urealyticum. Fifty-four (40.3%) of the specimens cultured positive for U. urealyticum. No significant differences were observed between infected and uninfected specimens for semen volume, sperm count, motility or morphology using the Student's t-test or nonparametric statistical analyses. These data confirm a previous investigation by our laboratory (Fertility and Sterility 36:648, 1981), but contradict two earlier reports implicating an adverse effect of U. urealyticum infection upon sperm motility. Investigations on the effects of the titre of U. urealyticum infection on semen parameters are presently being undertaken.

EFFECTS OF FEEDING AND DIAPAUSE ON OVARY DEVELOPMENT IN TIGER BEETLES. Betty E. Berry & C. Barry Knisley. Dept. of Biology, Randolph-Macon College, Ashland, Ba. 23005.

A laboratory study of the effects of prediapaue and postdiapaue feeding on winter survival and ovary development was conducted with Cicindela tranquebarica and Cicindela repanda. Beetles fed at low levels prior to diapaue had a significantly higher mortality during diapaue than beetles fed ad libidum. A period of diapaue was found necessary for females to reach sexual maturity. Feeding during postdiapaue must remain at high levels to insure proper ovary development. Beetles fed at low levels before diapaue gained a higher percentage of weight in postdiapaue than beetles at other feeding levels, and they also showed ovary maturation and egg production equal to beetles fed ad libidum during prediapaue. Thus low feeding levels in the fall can apparently be compensated for by high feeding in the spring.



FECAL COLIFORM AND FECAL STREPTOCOCCI ENUMERATION IN THE GREAT DISMAL SWAMP. Nancy W. Bourgeois\*, Dept of Biol., Old Dominion University, Norfolk, Va. 23508. Fecal coliform and fecal streptococci enumeration was done in the Great Dismal Swamp in Lake Drummond and Feeder Ditch during the months of June, July, and August. It was found that Lake Drummond is free from fecal coliforms. Fecal coliforms and fecal streptococci in Feeder Ditch increased from Lake Drummond to the Inland Waterway, suggesting that their source is land run-off through drainage pipes which were sampled. Increased rainfall corresponded to increased bacterial counts, supporting this idea. Fecal coliform to fecal streptococci ratios suggest that the land run-off is primarily from non-human storm-water run-off. Counts obtained for this study may be lower than counts obtained in a spring study due to higher water temperature and decreased rainfall and current flow in the summer.

A STUDY OF VARIATION IN EASTERN TIMBER RATTLESNAKES, CROTALUS HORRIDUS. Christopher W. Brown\*, Dept. of Biol., George Mason Univ., Fairfax, Va. 22124. Variation was examined in specimens of Crotalus horridus from the eastern United States in an attempt to substantiate the status of its two described subspecies as defined by Gloyd (1940). A particular effort was made to duplicate the results of a study by Pisani, et al. (1973), who concluded that no valid subspecies exist. A maximum likelihood factor analysis and stepwise discriminant analysis were performed on the same morphological characters used by Pisani, et al. (1973). Several additional characters relating to size and pattern were also examined.

DISPERSAL AND DISPERSION IN A POPULATION OF SOLDIER BEETLES, CHAULIOGNATHUS PENNSYLVANICUS. James R. Brown\* and Luther Brown, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Mark-recapture methods were used to examine movement patterns in a population of soldier beetles (Chauliognathus pennsylvanicus). Eighty-one percent of 776 marked beetles were recaptured 24 hours after release. Frequency distributions for distances moved were similar and leptokurtic for both sexes. Abundance of both males and females within the study site was highly correlated with presence of breeding sites and food (Solidago sp.). Partial correlation analyses suggest that males and females responded to Solidago plants in different ways: male density was positively correlated with plant abundance, female density was positively correlated with male abundance, and uncorrelated with plant abundance. Proportions of each sex remaining at a site were correlated with the density of the opposite sex, but uncorrelated with Solidago.

VARIABILITY IN DAPHNIA ACUTE TOXICITY DATA. Arthur L. Buikema, Jr., University Center for Environmental Studies and Department of Biology, Va. Polytechnic Institute and State University, Blacksburg, Va. 24061. Three independent labs acutely exposed Daphnia magna to 5 industrial effluents using a draft test protocol. Comparisons were made of percent survivors after 24 hr exposure to 100% effluent and 48-hr toxicity data. There was considerable intra- and inter-lab after 24 hr. Little intralab variability in 48-hr data was noted; however, there were significant interlab differences in 48-hr LC50s and dose-response slopes. Variation in results may be due to differences in test and culture conditions and genetic differences among animal stocks. Subcultures of the daphnid stocks were obtained and cultured under identical conditions for 50+ generations. Chromium exposed animals did not exhibit similar dose-response slopes suggesting that genetic differences may be a major factor in contributing to the variability in organism sensitivity to pollutants.

SIZE-RELATED PATTERNS OF OVARIOLE AND EGG NUMBERS IN A COMMUNITY OF TIGER BEETLES (COLEOPTERA: CICINDELIDAE). MARK C. CARTER AND C. BARRY KNISLEY. Dept. of Biology, Randolph-Macon College, Ashland, Va. 23005.

Body size was strongly correlated with ovariole number and mature egg size in fifteen species of Cicindela collected in southeast Arizona. Ovariole number was strongly correlated with reproductive number. These relationships suggest greater reproductive potential in larger beetles. No relationship between adult population size and reproductive potential was found, but that adult populations were dependent on habitat type. This indicates reproductive cell number is strongly environmentally influenced while ovariole number is constant within species.

THE EFFECTS OF PH ON SURVIVORSHIP AND GROWTH RATE IN THE FINGERNAIL CLAM, MUSCULIUM PARTUMEIUM (SAY) (PIVALVIA: PISIDIIDAE). Daniel L. Childers\* & Daniel J. Hornbach, Dept. Biol., Univ. of Va., Charlottesville, Va. 22901. The effects of pH on survivorship, growth and natality of a stream population of M. partumeium were examined in the laboratory by maintaining cultures of clams at pH 3, 4, 5, and 6 with  $H_2SO_4$  and a control (no acid; pH = 7). For individuals collected in October, the median survival times were 10.5, 24.0, 41.1, 47.1 and 62.1 days for pH 3, 4, 5, 6, and 7 (control), respectively, indicating that acidification had a great effect on survivorship. Clams maintained at pH 3 or 4 showed no growth (based on measures of shell length), whereas, clams at pH 5 displayed higher growth rates than those at pH 6 or 7 (control) (0.11, 0.07 & 0.06 mm/wk for pH 5, 6 & 7, respectively). Birth rates averaged 11 & 1 births/individual for 94 & 64 days for clams maintained at pH 5 and 7, respectively; no births were recorded for other treatments. This indicates that both rates of growth and reproduction are affected by acidification and that maximum rates are seen at a pH near that of the environment from which these individuals were collected (river approx. pH 5.2). Preliminary data on animals collected in January show the same general trends, but with variations in the specific survivorship, growth, and reproductive rates.

LIFE HISTORY TRAITS OF TWO POPULATIONS OF THE FRESHWATER CLAM, PISIDIUM CASERTANUM (POLI) (PIVALVIA: PISIDIIDAE) IN TWO SOUTHWEST VIRGINIA PONDS. C. Cox\* and D.J. Hornbach. Dept. Biol., Univ. Va., Charlottesville, Va. 22901. The 2 populations (FP & RP) studied inhabit ponds with different  $H_2O$  chemistry (e.g., conductivity 240 & 15  $\mu mho$  for FP & RP respectively) and display different life history characteristics. Shell lengths (SL) range from 0.7 to 3.3 & 4.8 mm for RP and FP respectively. Transfers were conducted to test for environmental influences on traits. For clams  $1.3 \leq SL \leq 2.0$  birth rates were equal in controls (RP→RP, FP→FP) while for clams  $>2.0$  birth rates FP→FP>RP→RP indicating greater overall fecundity in FP. Birth rates in FP→FP>FP→RP and RP→FP>RP→RP. Mortality was greater in FP→RP than in other transfers for all sizes of clams. These results indicate environment influences life history traits. Clams were cultured in waters of various hardness to test if increased Ca availability was responsible for observed life history difference. Mortality was greatest in softer waters, with RP>FP except in very soft where mortality was high in both FP & RP. Growth rates for clams  $SL \leq 1.2$  mm was greater in hard and control treatments. Thus,  $H_2O$  hardness affects life history traits. Electrophoresis indicates that there could be a genetic component to observed differences. RP has 1 genotype; FP has 2, with one being the RP type.

EFFECTS OF 6-METHOXYBENZOXAZOLINONE (6-MBOA) ON SEXUAL MATURATION IN SEVERAL RODENT SPECIES UNDER DIFFERENT PHOTOPERIODIC CONDITIONS. J. A. Cranford, Biology Dept., V.P.I. & S.U., Blacksburg, VA 24061. Photoperiod and the influence of 6-MBOA on sexual maturation was evaluated on several small rodent species (*Peromyscus leucopus*, *P. maniculatus*, *Microtus pennsylvanicus* and *M. pinetorum*). All species were tested under long (LD 16:8) and short (LD 8:16) photoperiods at 45 days of age. Under long photoperiod, 3 species were additionally evaluated at 30 and 35 days of age to examine age dependent effects. Minimum number of animals per group was 20 controls and experimentals of each sex and each photoperiodic condition. Animals were intraperitoneally injected with 0.5cc of control of experimental (5  $\mu$ g 6-MBOA) solution for 3 days with body weight, adrenal glands and reproductive organs assayed on the fourth day. Results showed a positive response for all species on long photoperiod while short photoperiod results varied. Those species tested at different ages indicate a strong age dependency in the response. Food consumption of long photoperiod groups was not different between controls and experimentals nor was body or adrenal weights. Experimental animals had lower body fat levels (Soxhlet extracted) than controls indicating that energy for sexual maturation was derived from existing fat energy reserves.

LOW TEMPERATURE EFFECTS ON GROWTH AND BODY WEIGHT IN *MICROTUS PINETORUM*. J. A. Cranford and N. Thumser, Biology Dept., V.P.I. & S.U., Blacksburg, VA 24061. The effect of cold ambient temperatures on growth, body weight dynamics and food consumption was determined for juvenile and adult *Microtus pinetorum*. Each age group was monitored through a warm temperature phase (20°C) followed by a short low temperature phase (1-5°C) and then returned to warm temperature. Animals were either housed singularly or multiply by sex to determine if huddling behavior would reduce the effect of low temperature exposure. Juveniles and adults differed in their response to cold period exposure, with juveniles showing continuous growth while adults lost weight. Singly and multiply housed pine voles differed in body weight maintenance but not in a consistent manner. Food consumption was higher in singly housed pine voles compared to multiply housed and during cold exposure both groups showed significant increases in food consumption. Singly housed cold exposed voles significantly increased food consumption relative to multiply housed voles. Other microtine species have shown body weight responses to photoperiod length changes similar to those observed in response to these temperature changes. Field data and controlled natural environment experiments indicate that body weight dynamics are more responsive to thermal changes than photoperiodic changes.

BREEDING BIOLOGY OF THE PURPLE MARTIN, *PROGNE SUBIS SUBIS*, IN WILLIAMSBURG AND JAMES CITY COUNTY, VIRGINIA. Robert R. Cross, Dept. of Biology, Christopher Newport Col., Newport News, Virginia. 23606. The purple martin is a member of the swallow family and breeds colonially in artificial nesting boxes throughout North America. In Williamsburg and James City County, the breeding success of this species was investigated via a banding project. Results indicate that purple martin populations are limited by strong interspecific and intraspecific competition for nest sites. Juvenile purple martins are often harassed on their initial flight from the nest of subadult martins. Two hypotheses have been proposed to explain this behavior. Implications of the strategy and motivation behind "juvenile harassment" are discussed.

EFFECTS OF HIGH AND LOW DIETARY PROTEIN LEVELS ON THE DIAMETER OF MUSCLE FIBERS OF THE MOUSE BICEPS BRACHII. L.M.DiClemente\*, A.F.Conway, and P.L.Dementi, Dept.of Biol., Randolph-Macon Col., Ashland VA 23005. The level of dietary protein received by mice was varied and the effect on muscle fiber size within the biceps brachii was measured. Eighteen mice were grouped by weight and fed control, high protein, or low protein diets. One group was weighed and sacrificed each day for 6 days. The muscle fibers of the biceps brachii were measured histologically. The mice on control and high protein diets showed moderate fluctuations in body weight while mice on low protein diets progressively lost weight. The mean fiber diameter in mice fed control or high protein diets was 19 microns but was reduced to 16 microns in mice on low protein diets.

SUBLETHAL EFFECTS OF THE WATER SOLUBLE FRACTION OF JP-4 JET FUEL ON THE BLUEGILL (LEPOMIS MACROCHIRUS). Thomas R. Doane\*, A. L. Buikema, Jr. & J. Cairns, Jr., Univ. Ctr. for Environ. Stud., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Equipment was developed to continuously deliver a water soluble fraction (WSF) of JP-4 jet fuel for exposure of bluegills. Analytical procedures were developed to determine the concentration of the WSF. The 96hr-LC50 of the WSF, tested in a flow through bioassay dilutor system, was determined to be 26% of the saturated WSF. A concentration of the WSF which caused a statistically significant shift in the ventilation rate, was 17% of the saturated WSF. Normal levels of ions and enzymes in the blood of the bluegills were determined. Changes in blood ion and enzyme concentrations were noted when fish were exposed to sublethal levels of WSF. Transmission electron micrographs were also taken of the gill and liver tissue from exposed fish. (Supported by a grant from the Air Force Office of Scientific Research.)

PARASITES OF THE OPOSSUM, DIDELPHIS VIRGINIANA, IN NORTHERN VIRGINIA. Ralph P. Eckerlin, Div. of Natural Sciences, Northern Va. Comnty. Col., Annandale, Va. 22003

Eleven species of metazoan parasites were recovered from 25 opossums collected in Fairfax Co. in northern Virginia. These included: Trematoda- Brachylaima virginianum; Cestoda- Mesocestoides corti; Nematoda- Capillaria sp., Cruzia americana, Longistrata didelphis, Physaloptera turgida; Acanthocephala- two unidentified immature specimens; Siphonaptera- Ctenocephalides felis, Orchopeas howardii; Acarina- Dermacentor variabilis, and unidentified immature mites. The immature acanthocephalans and mites may be accidental parasites of the opossum. The adult parasite species found are common parasites of the opossum in North America; however, several are new records for Virginia.

EVALUATION OF KODAK TECHNICAL PAN AND ILFORD XP-1 400 FILMS FOR ROUTINE BIOLOGICAL PHOTOGRAPHY. J.M.Emmett III\* and A.F.Conway, Dept.of Biol., Randolph-Macon Col., Ashland, VA 23005. Two new black and white negative films were evaluated under conditions routinely encountered in biological photography. Kodak Technical Pan was developed in diluted Edwal FG-7 or Kodak Technidol. Ilford XP-1 was developed in the Ilford XP-1 kit. These films were compared with Kodak Panatomic-X and Kodak Tri-X Pan developed in Kodak D-76. Technical Pan developed in Edwal FG-7 or Technidol produced a wider range of gray tones and much finer grain than Panatomic-X. Varying development time in Edwal FG-7 allowed adjustment of Technical Pan contrast to match the tonal range of the subject. Ilford XP-1 displayed more grain and less resolution than Technical Pan or Panatomic-X, but less grain than Tri-X. Resolution and sharpness were equal in XP-1 and Tri-X.

## FINE STRUCTURE OF AN OSMOREGULATORY ORGAN FOUND IN THE MITE FAMILY ALGOPHAGIDAE.

Norman J. Fashing, Dept. of Biol., Col. of William & Mary, Williamsburg, Va. 23185. Mites of the astigmatid family Altophagidae are characterized by an elevated sclerotized band of cuticle on each side of the propodosoma between legs I and II ("axillary organs"). Scanning and transmission electron microscopy of these organs in Altophagus pennsylvanicus, a species found in water-filled treeholes, reveals a porous plate covering specialized epidermal cells which contain plasma membrane plications in close contact with numerous mitochondria. Such cells are typically involved in active transport. Morphologically similar structures have been found to function in osmoregulation in aquatic insects, and the same is probably true for the axillary organs of this family of aquatic mites.

EFFECTS OF INTRAFOLLICULAR INJECTION OF A VOLUME EXPANDER ON OVULATION IN THE RABBIT. Kathryn P. Flagge and R. J. Swanson, Dept. of Biological Sciences, Old Dominion Univ., Norfolk, VA 23508. Intrafollicular injection of solutions into rabbit ovaries *in vivo* was accomplished with sharpened, beveled, and smoothed glass microneedles having bore diameters ranging from 5-25 micrometers. Needles were fitted with plastic tubing, which was attached to a 5 microliter Hamilton syringe loaded with the appropriate solution for injection. Surgery was performed on mature female New Zealand rabbits two to three hours post coitus. With an ovary exposed, randomly selected Graafian follicles were either: (1) injected with physiological saline, (2) injected with 2% Blue Dextran (MW 2,000,000) in physiological saline, or (3) left uninjected. All follicles visible at the time of ovarian exposure and any administrations to these follicles were indicated on a reference map used for orientation upon histological examination of the ovary following its removal 18 1/2 to 23 hours postovulation. Evaluation of follicular status (ovulated or non-ovulated) at the time of ovarian excision was performed within and among the test and control groups. Intrafollicular pressure was not recorded.

AN OSTEOLOGICAL OVERVIEW OF THE SEVEN PERCINA SPECIES IN THE SUBGENUS ALVORDIUS (PISCES:PERCIDAE). Ann S. Fulcher\* and W. S. Woolcott, Dept. of Biology, Univ. of Richmond, VA., 23173. An osteological investigation was conducted to determine the phylogenetic relationships among seven Percina species, subgenus Alvordius. Specimens were examined using X rays and an enzymatic clearing and staining technique. Diagnostic skeletal characters included the coracoid, premaxilla, dentary, and hypurals. Preliminary findings indicated that (1) P. maculata is representative of an earlier ancestral stock and (2) P. macrocephala and P. pantherina, which occur west of the Appalachian Mountains, are similar and differ from the eastern species P. crassa, P. notogramma, P. peltata, and P. roanoka which appear morphologically closer to P. maculata. (Supported in part by a University of Richmond Undergraduate Grant)

DIURNAL AND SEASONAL INFLUENCES ON THE METABOLIC RATE OF THE ASIATIC FRESHWATER CLAM, CORRICULA FLUMINEA (MÜLLER) (BIVALVIA: CORRICULIDAE). S.E. Gardner\* & D.J. Hornbach, Dept. of Biol., Univ. of Va., Charlottesville, Va. 22901. Metabolic rates ( $V_{O_2}$ ) were measured on a daily basis at 3 periods throughout the spring (groups I, II, & III collected 31 March, 22 April, 10 May 1982, respectively). Significant variations in  $V_{O_2}$  occur on a daily basis (as much as 76% for 2 mg clams of group I), and in a rhythmic pattern with 2 periods of high and 2 periods of low activity at approximately 1300 & 2000 h and 0900 & 1700 h, respectively. Daily changes in  $V_{O_2}$  may be associated with energy requiring osmoregulation since variations and rhythmicity of reported rates coincide. It is also possible that the diel patterns reported are representative of a portion of the circadian rhythmicity in physiological functions of Corbicula. Greatest  $V_{O_2}$  and the most pronounced diel rhythms were seen in group II, while lowest  $V_{O_2}$  (as much as 79% below rates for group II clams) and smallest variations were recorded for group III. Shell length-ash free dry weight relations changed during this study with group III showing more tissue weight per unit shell length than group I. It is suggested that this might be the result of this population becoming reproductively active. The changes in  $V_{O_2}$  from group to group are probably the result of the clam's changing reproductive status.

THE USE OF OTOLITHS FOR DETERMINING DAILY AGES OF YOUNG-OF-THE-YEAR SMALLMOUTH BASS. Robert J. Graham\*, Dept. of Fish. and Wildl. Sci., Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061. Viable smallmouth bass eggs were collected from a wild nest on 26 May, 1982 and hatched under laboratory conditions to determine if the growth rings on the saggitae of young-of-the-year smallmouth bass were daily rings as suggested by previous otolith research. Ten smallmouth bass were removed from the laboratory culture every other day from the time of swim-up until 14 days after swim-up, frozen, and the saggitae later examined for growth rings. Results indicate that saggital growth rings are laid down on a daily basis with the first daily growth ring laid down within one day of larval swim-up. Techniques for the preparation and reading of smallmouth bass saggitae are discussed. Examination of the saggitae of young-of-the-year smallmouth bass collected from 5 study sites within the New River drainage disclosed simultaneous spawning occurred during 1982, with a minor spawn of short duration occurring in late May and a major spawn of longer duration occurring during the last three weeks of June.

ESTUARINE DEMERSAL FISH: A STUDY OF SPECIES DIVERSITY TRENDS IN A NEW ENGLAND FISH COMMUNITY. Mary C. Hager\* & A.J. Bulger, Jr.\*, Dept. of Biol., Univ. of Va., Charlottesville, Va. 22901. Species diversity indices are frequently used to describe community structure. Classical studies comparing diversity trends have concluded that estuaries are characteristically species poor, a result of their exposure to extreme physiological stresses. These studies have been based primarily on sessile invertebrates. An examination of fish, however, has produced diversity indices that are quite high. Otter trawl samples of demersal fish in Long Island Sound and Narragansett Bay were taken during a five-day period in June 1982. Comparison of these samples with those of previous year-round studies of the region suggest that the estuarine fish community does not exhibit the predicted trend of low species diversity. Explanations for this phenomenon include the physiological and migratory capabilities of these species.

EFFECTS OF HEXAVALENT CHROMIUM ON GROWTH AND REPRODUCTION OF CHIRONOMUS RIPARIUS (DIPTERA). C. L. Hax and A. L. Buikema, Jr., Biol. Dept., Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24061. The effects of chromium (VI) on the complete life cycle of Chironomus riparius were examined in the laboratory, using both a sublethal (0.5 mg/l) and a 50% lethal (2.0 mg/l) concentration. Chironomus egg masses were introduced into both control and chromium treated 5-gal. aquaria. Larvae were subsampled at 5-day intervals, measured for length, and weighed to generate a growth curve. Emerging adults were allowed to mate and oviposit. Growth rates of larvae exposed to 0.5 mg/l and 2.0 mg/l were significantly higher than controls. Reproductive success, as measured by the number of offspring produced per adult female, declined with increasing chromium concentration. Adult weights and chromium body burdens in females did not differ significantly between treatments and did not explain the observed decrease in reproductive success.

EVALUATION OF SEAFOOD PROCESSING WASTES AS A PROTEIN SOURCE IN RAINBOW TROUT DIETS. L. A. Helfrich, J. C. Dean, D. L. Weigmann, and L. A. Nielsen. Dept. of Fisheries & Wildl. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, Va. 24061. Disposal of seafood processing wastes is a significant problem for the seafood industry. In this study, we compared the growth response, survival, and feed conversion efficiency of cage-cultured rainbow trout (Salmo gairdneri) fed a control diet (Purina Trout Chow) with two experimental diets containing either herring (Clupea harengus) cannery residue or blue crab (Callinectes sapidus) scrap to evaluate the feasibility of using seafood wastes as dietary protein supplements in pelleted trout rations. One hundred rainbow trout fingerlings (40 g average) were stocked into each of nine floating cages (1 m<sup>2</sup>) and fed one of the three diets of 3% of live body weight per day for 179 days. Growth, production, survival, and feed conversion efficiency were significantly greater ( $p < 0.05$ ) for trout reared on the control diet than either of the experimental diets. Growth, production, and feed conversion were significantly greater for trout reared on herring scrap than on the crab waste diet. Survival rates were similar for both experimental diets.

AVIAN DISPERSERS OF EASTERN RED CEDAR (JUNIPERUS VIRGINIANA L.) AND THEIR INFLUENCE ON THE SPATIAL DISTRIBUTION OF THE RED CEDAR SEED SHADOW. A.M.A. Holthuijzen\* and T.L. Sharik, Dept. Fish. and Wildl. Sci. and Dept. Biol., VPI & SU, Blacksburg, VA 24061. Eastern red cedar is mainly dispersed by birds, by passage of seeds through the gastro-intestinal tract. Eight species of birds were observed feeding on red cedar cones; yellow-rumped warblers, cedar waxwings, robins and starlings were the most commonly recorded species. Size of the red cedar fruitcrop was positively correlated with disperser abundance (no. dispersers/hour). Disperser abundance was positively correlated with the numbers of seeds voided by birds and collected in the field, but not with red cedar fruitcrop depletion. Flock feeding species (e.g., cedar waxwings) caused rapid depletion of cedar fruitcrops. Red cedar dispersers can be divided into two groups: (1) consistent single foragers, providing local dissemination, and (2) flock feeders, occurring irregularly over time, which provide widespread long-distance dispersal.

EASTERN RED CEDAR (*JUNIPERUS VIRGINIANA* L.): AN EXAMPLE OF A PIONEER SPECIES WITH A HIGHLY EFFICIENT DISSEMINATION SYSTEM. A.M.A. Holthuijzen\* and T.L. Sharik, Dept. Fish. and Wildl. Sci. and Dept. Biol., VPI & SU, Blacksburg, VA 24061. Seed dispersal theory predicts that pioneer woody species, producing fruits relatively high in carbohydrates and water, are mainly dispersed by opportunistic frugivores, which provide low quality dispersal. Low quality refers to (1) damage to the seeds by dispersers during ingestion or during passage through the gastro-intestinal tract, and (2) a large proportion of the fruitcrop wasted by dispersers. Red cedar produces large crops of small cones eaten by a variety of avian frugivores. Opportunistic frugivores, like the yellow-rumped warbler, provided reliable dispersal and greatly enhanced germination of the seeds. The cedar waxwing, the only frugivores specialist, enhanced germination only slightly and provided unreliable dissemination. A large proportion of the fruitcrop of pioneer species is in general wasted. However, 73% of the red cedar fruitcrop was deposited beyond the canopy projection of the red cedar seed sources.

EFFECTS OF ACCLIMATION TEMPERATURE AND BODY SIZE ON THE METABOLIC RATE OF THE FRESHWATER CLAM, *MUSCULUM PARTURIUM* (SAY) (BIVALVIA: PISIDIIDAE). D.J. Hornbach, Dept. Biol., Univ. Va., Charlottesville, Va. 22901. Metabolic rates ( $V_{O_2}$ ) were determined for 8 size-classes of clams for each of 16 treatments;  $V_{O_2}$  measured at each of 4 run temperatures (RT = 5, 10, 15 & 20°C) for animals acclimated to 4 temperatures (AT = 5, 10, 15 & 20°C). For all treatments, except AT=5-RT=5,  $b$ -values from  $V_{O_2}=aAFDW^b$  (AFDW=tissue weight) were not significantly different from 1, thus  $Q_{O_2}$  ( $V_{O_2}/AFDW$ ) is a constant for all sizes of clams.  $Q_{O_2}$  varied from 0.40 - 2.46  $\mu l O_2/mg/hr$  for treatments AT=10-RT=5 and AT=15-RT=20 respectively. ANOVA on these 15 treatments (all except AT=5-RT=5) indicated that both AT and RT, and their interaction significantly affect  $Q_{O_2}$ .  $Q_{O_2}$ , when RT = 10 or 15, was higher for AT = 20 than AT = 5, 10, or 15 (reverse compensation); AT had no effect when RT=5 (no compensation).  $Q_{O_2}$ 's = 1.0 over the interval 10-15°C, regardless of AT, while  $Q_{O_2}$ 's were >1.0 over other intervals. The  $b$ -value, from  $V_{O_2}=aAFDW^b$ , for AT=5-RT=5 was 0.504, indicating that small clams had higher  $Q_{O_2}$ 's than large clams (e.g.  $Q_{O_2}$  = 2.19 and 0.22 for 0.03 & 3.00 mg clams respectively). Thus at low temperatures, size influences acclimation pattern (small to large clams display the entire range of compensatory patterns; over to reverse compensation).

BLOOD GLUCOSE LEVELS, DEPOT FAT, AND SURVIVAL TIME IN THE BILATERALLY ADRENALECTOMIZED MONGOLIAN GERBIL (*MERIONES UNGUICULATUS*). A. B. Jefferson\* and F. B. Leftwich, Dept. of Biology, Univ. of Richmond, VA., 23173

Forty Mongolian gerbils were bilaterally adrenalectomized and treated with injections of cortisol (1 mg/2 days) and/or 5% sucrose drinking solution. Cortisol was found to cause a significant ( $p < 0.05$ ) increase in survival time of ADX gerbils (5.57 days vs. 3.57 days) and a significantly greater percentage loss of body weight over the course of the experiment, although the average percentage of weight lost per day was not significantly different for any group.

Plasma glucose levels, measured on the third postoperative day, were significantly higher in ADX gerbils treated with cortisol than in untreated gerbils. No difference was found in either the weight of depot fat or the lipid content of depot fat under any treatment. The gerbils are not believed to have utilized any of the 5% sucrose solution, and sucrose was not found to have an effect on any parameter measured.



ELECTROPHORETIC ANALYSIS OF HUMAN SERUM FOR CELL CULTURES. Evelyn W. Jemison and Angela D. Smith. Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

This investigation is designed to determine specifically the protein composition of human serum fractions by electrophoretic analysis. Human serum was substituted as a growth factor for fetal calf serum (Jemison, Goad, and Robinson 1981) and was reported ineffective for the maintenance of lymphocyte growth cultures, thus, protocols were developed to identify the inhibitory proteins. The human serum fractions were produced by DEAE column chromatography and identified by the colored bands absorbed. Eluted fractions were electrophoresed on cellulose acetate and acrylamide gel for identification of proteins and protein subunits. We will report the electrophoretic patterns of the human serum fractions. This research was supported by NIH/MBRS GRANT Number RR-08090-11 and NIH/MARC GRANT Number GM-07678.

HUMAN SERUM FRACTIONS AS FETAL CALF SERUM SUBSTITUTE IN CELL CULTURE. Evelyn Jemison and Thomas Wright. Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

Diethylaminoethyl (DEAE) cellulose extracted chromatographic fractions are being used as a fetal calf serum substitute in the lymphocyte test system. These experiments are designed to test for consistent effects when human serum fractions of variable amounts are employed as growth factors. In order to determine the in vitro effect, parameters being measured are growth rate, morphology and ploidy. Preliminary results suggest definitive cytotoxic effects when cells are exposed to human serum fractions. Experiments are in progress to more completely assess the cytogenetic effects of the eluted serum fractions. This research was supported by NIH/MBRS GRANT Number RR-08090-11.

MICRO-TITER ANALYSIS OF DNA SYNTHESIS OF HUMAN LYMPHOCYTES EXPOSED TO CALCIUM CYCLAMATE. Jemison, E. W., and Little, D. M., Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

Micro-titer analysis of DNA synthesis was used as a quantitative measurement along with the proliferation of PHA stimulated human T-lymphocytes in vitro. After 24 hours ( $T_{24}$ ) lymphocyte cultures were exposed to a calcium cyclamate concentration of  $1.0 \times 10^{-6}$  gm/ml. Nine hours prior to cell harvest lymphocyte cultures were inoculated with tritiated thymidine (14.47 m ci/ml). The  $T_{22}$  lymphocytes were harvested on glass filter pads (mini-MASH). Radiotracer activity of each microculture was determined by scintillation counting. Data collected on lymphocyte cultures that were exposed to calcium cyclamate indicated a lower activity than the control. These results are consistent with those obtained in previous studies which used a macro system of determining the rate of DNA incorporation in cyclamate exposed cells. This research was supported by NIH/MBRS GRANT Number RR-08090-11.

SISTER CHROMATID EXCHANGE PATTERNS AS PRODUCED BY HUMAN SERUM FRACTIONS. Evelyn W. Jemison and Cornell H. Jones. Cytogenetics Laboratory, Department of Life Sciences, Virginia State University, Petersburg, Virginia 23803.

This report is of an investigation designed to monitor cytological, chromosomal and growth rate changes in cells cultivated in human serum fractions. Fractions were eluted during DEAE cellulose chromatography and substituted for fetal calf serum in the tissue culture growth medium. The sister chromatid exchange method is employed as a sensitive means of assessing chromosomal exchanges in vitro, which may be indicative of mutagenic effects or toxic effects. Preliminary results have shown chromatid exchange in the presence of fraction one serum fraction. This report will also present data regarding proliferative rates and cell morphology. This research was supported by NIH/ MBRS GRANT Numer RR- 08090-11.

EVALUATION OF OLIGOSPERMIC HUMAN SPERM WITH ZONA-FREE HAMSTER OVA. Keith Jones and R. James Swanson, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, VA 23508. Hamster ova, stripped of cumulus oophorous and zona pellucida by hyaluronidase and trypsin, respectively, have been used by a number of laboratories to evaluate the ability of human sperm to penetrate the oolemma. In this experiment, a group of suspected infertile, oligospermic sperm samples was compared to a group of proven fertile sperm samples. Nine specimens having a count below  $5 \times 10^6$  sperm/ml had a 4.7% mean penetration. Four samples falling between  $5$  to  $20 \times 10^6$  sperm/ml had an 18.8% mean penetration. Fifteen specimens having a count above  $20 \times 10^6$  sperm/ml had a 40.4% mean penetration. Severe oligospermia may have an adverse effect on sperm penetrability of the oolemma.

EFFECTS OF WATERSHED URBANIZATION ON STREAM INSECT COMMUNITIES. R. Christian Jones and Christopher C. Clark\*, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. The effect of watershed urbanization on stream insect communities was quantified by sampling streams draining thirty watersheds in northern Virginia ranging from highly urbanized Tripps and Holmes Runs to entirely forest Quantico Creek. Forest streams contained diverse fauna including species of Ephemeroptera, Trichoptera, Odonata, Diptera, Coleoptera, and Plecoptera. The most highly urbanized streams contained only Diptera, Trichoptera, and Ephemeroptera. Insect abundance was usually lowest in the most urbanized streams, except below reservoirs where Trichoptera were extremely abundant. These results suggest that stresses resulting from watershed urbanization deplete the stream insect fauna.

EFFECT OF MILK REMOVAL ON TRANSFER OF PROLACTIN FROM BLOOD INTO MILK IN DAIRY COWS. Ray M. Kaplan\* and R. Michael Akers, Dept. of Dairy Science, VPI&SU, Blacksburg, VA 24061. Three experiments were conducted to study the effect of milk secretion rate on prolactin (PrI) transport into milk. Foremilk, primary and residual milk samples (N=16) had similar PrI concentrations. Four cows were milked 2, 4, 8, and 16 hours after an initial milking. Milking interval had no effect on PrI concentrations, however, total PrI transported into milk ( $1.1 \mu\text{g}:2 \text{ h}$  to  $18.4 \mu\text{g}:16 \text{ h}$ ) increased with milk production. PrI was also infused IV (N=3) for 10 h to determine the effect of increased serum PrI on transport. Serum levels increased from  $32 \pm 5$  to  $69 \pm 1 \text{ ng/ml}$ . Concentrations of PrI in the milk of active glands increased 82% by the end of infusion compared with 21% in unmilked mammary glands. Total PrI transported during infusion was also greater in actively secreting glands ( $109 \pm 23$  vs  $45 \pm 10 \mu\text{g}$ ). Results indicate that increased serum PrI has little effect on milk PrI in the absence of active milk secretion.

THE ROLE OF DIFFERENTIAL VISIBILITY IN SIZE-SELECTIVE ZOOPLANKTIVORY BY BLUEGILL SUNFISH. William E. Kelso\* and John J. Ney, Dept. Fish. Wildl. Sci., VPI & SU, Blacksburg, Va. 24061. Size-selectivity by zooplanktivorous fish has frequently been reported and may exert a controlling influence on the composition of lentic zooplankton communities. Laboratory studies have shown that size-selection may be attributed to differential visibility of zooplankton to their predators, but this explanation has not been subjected to field verification. We collected juvenile specimens of the bluegill, a facultative planktivore, and zooplankton concurrently from Claytor Lake, Virginia, and compared length frequency distribution of zooplankton in gut contents and water column samples. Bluegills demonstrated size selection. Application of a differential visibility foraging model to the water column zooplankton size distribution failed to account for the observed prey selection. Other factors (zooplankton behavior and diversity, habitat complexity) appear to override visual discrimination in the selection of zooplankton by lentic bluegill.

CHARACTERIZATION OF A SMALL ACCESSORY CHROMOSOME FOUND IN A NORMAL HUMAN FEMALE. Alice J. Kutteroff\* and Stanton F. Hoegerman, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185. A small accessory chromosome was first found in a college student and later in her only sib (a sister) and in their mother. All are phenotypically normal and of high intelligence. The accessory appears to be monosatellited but silver staining revealed the presence of nucleolus organizer regions (NORs) on both arms. One NOR, which is probably located on the obviously satellited arm, is conspicuously larger than the second NOR. The accessory is probably monocentric as it contains very little, if any, C-band positive chromatin. These observations argue for origin of the accessory chromosome by Robertsonian translocation.

SOURCES OF VARIABILITY IN THE ACCUMULATION OF HEAVY METALS BY BLUEGILL SUNFISH AND CHANNEL CATFISH IN A VIRGINIA RESERVOIR. Mallory G. Martin\* and John J. Ney, Dept. of Fish. Wildl. Sci., VPI & SU, Blacksburg, Va. 24061. Variability in reported trace metals concentrations of fishes is high, but factors affecting bioaccumulation are poorly understood. We examined the relation of duration of exposure (age) to whole-body concentrations of Cd, Pb, and Zn in fishes from a metal-contaminated area of Claytor Lake, Virginia. We further reasoned that concentrations at age should be higher in benthic catfish than the more pelagic sunfish. Significant ( $P < 0.05$ ) positive correlations were obtained between age and metals concentration ( $\mu\text{g/g}$ , D.W.) for Pb in both species; age-concentration correlations were significantly negative for Zn. Cd differed significantly but inconsistently among catfish age groups. Between species, catfish were significantly higher in Pb and lower in Zn than bluegills; no interspecific differences were evident for Cd.

EFFECT OF LEAF LEACHATES ON COLONIZATION OF ARTIFICIAL SUBSTRATES. Paul McCormick\*, J.R. Pratt\*, P.M. Stewart, and J. Cairns, Jr., Dept of Biol. and Ctr. for Environmental Studies, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Secretions from aquatic macrophytes have inhibitory effects on phytoplankton, invertebrates, and macrophyte seedlings. Protozoan colonization of artificial substrates in Pandapas Pond, Montgomery Co., Va. was depressed near monospecific Typha latifolia stands relative to other areas of the pond. Microbial colonization was tested in laboratory microcosms filled with pasteurized leachates of Typha stems and Quercus leaves and a control of pasteurized water. Results of colonization trials indicated no significant differences in protozoan colonization; however, diatom colonization rates differed in each of the three treatments. Diatom colonization was depressed in Quercus leachates and elevated in Typha leachates. Fluorometric and spectrophotometric analyses showed different levels of ring and double-bonded carbon compounds in the leachates. Results suggest that complex leachates may inhibit periphytic microbial species.

GREAT HORNED OWL RESPONSE IN YOUNG VERSUS OLD-GROWTH FOREST STANDS. Kevin McGarigal & James Fraser, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. To assess the impact of stand age and associated vegetation structure on great horned owl (Bubo virginianus) populations, we compared the frequency of owl response to tape recorded vocalizations in 24 young-growth (<80 years old) forest stands with the response frequency in 25 old-growth (>80 years old) forest stands. Stands were randomly selected from a list of all stands on the Blacksburg Ranger District of the Jefferson Nat. Forest. Owls responded at 5 of 25 old-growth stands and 1 of 24 young-growth stands ( $\chi^2 = 2.86$ , 1 df,  $p = .09$ ). The results indicated that more responses were obtained at stands adjacent to farmland. Therefore, we fit a model to the data using response and adjacency to farmland as variables. Responses were obtained at 5 of 17 stands within 1 km of farmland compared to only 1 of 32 stands not within 1 km of farmland ( $\chi^2 = 7.14$ , 1 df,  $p = .008$ ). A 3-dimensional model including both stand age and farmland variables, which assumed all 2-way interactions but no 3-way interaction, did not fit the data well ( $G^2 = 7.25$ , 1 df,  $p = .008$ ) suggesting that owls occur more frequently where old-growth and farmland are juxtaposed than in other areas.

INDUCTION OF ESTRUS IN WHITE-TAILED DEER. Kevin McGarigal & P. F. Scanlon, Dept. of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061. Attempts were made to induce estrus in adult female white-tailed deer (Odocoileus virginianus) prior to the normal breeding season (late November). Progestagen treatments were given for 10 days starting 11 October by intra-vaginal sponge-pessaries (medroxyprogesterone acetate, MAP, Upjohn, 60 mg) in 5 does or by subcutaneous silastic implants containing 75 mg melengestrol acetate (MGA, Upjohn) in 5 does. At progestagen withdrawal FSH (FSH-P Armour-Baldwin) was given i/m, 10 Armour units (AU) or 15 AU to does. All treatments were randomly allocated. Estrus was checked using 2 intact adult male deer to which the does were exposed every 12 hours from 20 to 80 hours after progestagen withdrawal. One pessary was lost by a doe. All 4 remaining pessary-treated deer elicited teasing responses by the males (2 were teased, 1 was the subject of persistent teasing, and one was bred by the male). Of the 5 implant-treated does only 1 elicited persistent teasing by the males--all others provoked no response by the males. Effectiveness of treatment in inducing estrus may have been limited by the timing and single-dose nature of the FSH injection and by the relative lack of interest of the male deer.

NOTES ON THE BIOLOGY OF ALGOPHAGUS PENNSYLVANICUS, A MITE INHABITANT OF WATER-FILLED TREEHOLES. Donna L. Middleton & Norman J. Fashing, Dept. of Biol., Col. of William & Mary, Williamsburg, Va. 23185. A survey of water-filled treeholes in Cook Forest State Park, Pa., revealed that 54% contained Algothagus pennsylvanicus. A similar survey in southwestern and eastern Virginia, however, indicated a patchy distribution in this region with few treeholes containing this species. Investigations on feeding behavior were carried out by rearing mites on leaves as well as on various microbial isolates from treeholes (fungi, actinomycetes, bacteria). The ability to develop to adulthood and to reproduce was used as a measure of success. Mites were reared most successfully on fungi. Scanning electron microscopy of leaf surfaces on which mites had grazed revealed only small amounts of fungi when compared to controls, and SEM micrographs of mouthparts revealed adaptations for grazing. Therefore, A. pennsylvanicus feeds by grazing on fungi, in contrast to Naiadacarus arboricola, another mite inhabitant that feeds on decomposing leaves within the treeholes.

NON-LETHAL PREDATION IN TEREBRA DISLOCATA (GASTROPODA). Ronald S. Mollick, Dept. of Biol. and Environ. Sci., Christopher Newport College, Newport News, Va. 23606. T. dislocata has been commonly reported as a deposit feeder. In nature it was found concentrated in the casting piles of the hemichordate Balanoglossus aurantiacus. Laboratory studies (ATP, organic carbon) on casting piles and deposit feeding habits ruled out that mode of life. Food preference studies demonstrated that T. dislocata is a specialized predator feeding on the posterior sections of the hemichordate which typically loses only a fraction of its body. Since the hemichordate can regenerate lost body parts it therefore is capable of providing a continuous yield of food. This relationship was termed non-lethal predation which may play a significant role in the trophic dynamics of T. dislocata and other organisms.

ULTRASTRUCTURE OF OCTOPUS MYOCARDIUM. Laura L. Monfalcone & C. P. Mangum, Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185. Transmission electron micrographs of the systemic ventricle of Octopus bimaculatus reveal a cross-striated organization of the myocardial fiber. Sarcomeres are delineated by Z-bodies and filament bands, although A and I bands are not discernible. Mitochondria are abundant and they contain many cristae. The extensive reticulum includes a t-tubule-like system connecting subsarcolemmal vesicles to the interior of the myofibrils along the level of the Z-bodies. No cell junctions were observed. An unusual component, a membrane bound muscle bundle, was found in sections from both the periphery and the interior of the tissue. This filament-dense bundle and its associated mitochondria stain much darker than the surrounding myocardial tissue, which is of the general type found throughout the ventricle. These results indicate that the fundamental features of the octopus myofiber resemble those found in other advanced cephalopods, which differ conspicuously from the primitive Nautilus.

SMALL MAMMAL TRAPPING SUCCESS IN "NO-TILL" SOYBEAN FIELDS. W. Edward Montz, Jr., Patrick F. Scanlon, Jack A. Cranford and Roy L. Kirkpatrick, Dept. of Fisheries & Wildlife Sciences, and Dept. of Biol., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061. Live-trapping was conducted in and around two soybean fields employing "no-till" farming practices in which soybeans were planted as a second crop in wheat stubble remaining from the previous crop. A total of 32 small mammals (30 Mus musculus, 1 Rattus norvegicus, 1 Peromyscus leucopus) were trapped over 574 trap-nights (5.6% overall trapping success). Fourteen animals were trapped in 3 trapsects placed on field edges over 427 trap-nights effectively sampling 11,250 m<sup>2</sup> resulting in a mean estimated density of 11.8 animals/ha. Seventeen animals were trapped in two grids placed in field interiors over 144 trap-nights sampling 3,375 m<sup>2</sup> producing an estimated mean density of 50.5 animals/ha. Trapping success was significantly ( $P < 0.0005$ , Chi-square = 42.4, 1 d.f.) greater in field interiors than around edges. Differences in trapping success indicate that "no-tilled" fields may create favorable micro-habitats for small mammals by creating shade, by lowering ambient temperatures during warm summer growing seasons, by increasing food supply (insects, weed seeds, vegetation) and by enhancing escape cover.

EFFECTS OF THE ORGANOPHOSPHATE INSECTICIDE, PARATHION, ON REPRODUCTIVE CHARACTERISTICS IN Sylvilagus floridanus. W. Edward Montz, Jr., Roy L. Kirkpatrick & Patrick F. Scanlon, Dept. of Fisheries & Wildlife Sci., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061. Cottontail rabbits, Sylvilagus floridanus, were live-trapped and placed in 0.10 ha enclosures in a deciduous woodlot. Treated female cottontail rabbits were given two 8 mg doses of ethyl parathion per kg body weight orally. No significant differences ( $P > 0.05$ ) were detected in fertility rate, litter size or weight, or weights of any of the internal organs measured when treatment groups were compared with controls. Peri-renal fat weights were significantly lower ( $P < 0.05$ ) in treated animals compared with controls. A subsequent laboratory experiment revealed that parathion treatment caused animals to cease eating for 2 da following treatment. After this period of depressed food consumption, intake increased above that of controls suggesting compensatory feeding.

EFFECTS OF FIELD APPLICATION OF THE CARBAMATE INSECTICIDE, METHOMYL, ON BRAIN ACETYLCHOLINESTERASE ACTIVITIES IN Mus musculus. W. Edward Montz, Jr., Patrick F. Scanlon, & Roy L. Kirkpatrick, Dept. of Fisheries and Wildlife Sci., Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061. Free-ranging Mus musculus were live-trapped to determine the effect of Lannate (methomyl, 1.8EC, 2.3 l/ha) on brain acetylcholinesterase activity of field collected mice and to evaluate live-trapping as a technique for collecting insecticide-intoxicated small mammals from soybean fields. Mean brain acetylcholinesterase activities over the 3 da collection period were significantly reduced ( $P < 0.10$ ) 11.2% below mean control activity. Maximal depression of 12.3% brain acetylcholinesterase activity occurred on the third day after spraying. Live-trapping is effective in collecting animals exhibiting brain acetylcholinesterase inhibition although a conservative sampling bias is probable. We conclude that measurable intoxication of field populations of small mammals may occur even when anticholinesterase insecticides are applied at recommended label rates and that M. musculus is a useful representative animal for investigations involving warm-blooded animals. (This study was supported, in part, by the Virginia Commission of Game and Inland Fisheries).

FAT-SOLUBLE CHEMICAL RESIDUES IN BOBWHITE QUAIL FROM VIRGINIA. W. Edward Montz, Jr., Patrick F. Scanlon, Richard G. Oderwald, Roderick W. Young, Roy L. Kirkpatrick, and Jack V. Gwynn, Dept. of Fisheries & Wildlife Sciences, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061. Bobwhite quail (Colinus virginianus) wings (N = 160, 80 adults, 80 juveniles from a total of 5 counties) recovered from hunters during the 1981/1982 hunting season in Virginia were tested for fat soluble organic chemicals. Fat was extracted from wings after feather removal and analyzed by gas chromatography procedures. Measurable quantities (range, ppm) of chemicals were found as follows: PCB's in 46 of 160 (0.1-2.55); total DDTs in 58 of 160 (0.05-6.12); Heptachlor in 98 of 160 (0.08-9.50); Heptachlor epoxide in 57 of 160 (0.02-3.59); Dieldrin in 75 of 160 (0.03-7.04); Dursban in 58 of 160 (0.12-16.32); HCB in 41 of 160 (0.01-3.38); Diazinon in 24 of 160 (0.01 - 2.93); BHC in 16 of 160 (0.05 - 4.13). Others found were Paarlol in 3, Lindane in 3, Chlordane in 5, Aldrin in 7, Mocap in 2, Toxaphene in 1 and Methoxychlor in 3.

ANATOMICAL EVIDENCE FOR SYNCHRONIZATION OF FAST TOADFISH SWIMBLADDER MUSCLE. Paul J. Mosca\* & Michael L. Fine\*, Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284. Communicatory sounds are produced by rapid contraction of fast sonic muscles on the swimbladder of the oyster toadfish Opsanus tau. The muscle contracts in almost perfect synchrony, i.e. there is an 0.3-0.5 msec difference in onset of an action potential between the cranial and caudal ends of the muscle over a length of 40-50 mm (Skoglund, 1961). We looked for anatomical evidence of this synchronization by examining the position of labeled neurons within the sonic motor nucleus (SMN) after retrograde transport of horseradish peroxidase injected into rostral, mid, and caudal regions of sonic muscle. Regardless of injection site, motor neurons throughout the rostral-caudal extent of the SMN were filled with reaction product. Differences between regional labeling pattern within the SMN are minor and inconsistent. We conclude that there is no obvious somatotopic projection of SMN neurons upon sonic muscle fibers, and therefore, that all the fibers in the muscle will be activated at approximately the same time. Supported by Virginia Commonwealth University biomedical-grant-in-aid.

DEVELOPMENT OF THIN SECTIONING AND ACETATE PEEL TECHNIQUES FOR DETERMINING AGE AND GROWTH PARAMETERS OF FRESHWATER MUSSEL POPULATIONS. Steven N. Moyer & Richard J. Neves,\* Dept. of Fish. & Wildl. Sci., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061. Age and growth characteristics of freshwater mussels are determined almost exclusively from external growth checks on shells. However, shell erosion, environmentally-induced checks, and the obscurity of growth lines near shell margins usually result in only approximate ages for this faunal group. Two internal shell aging methods, thin sectioning and acetate peel techniques, were developed to obtain greater accuracy and precision in determining specimen ages. Thin sectioning makes use of a low speed, diamond-blade saw to cut 250  $\mu$ m cross-sectional slices of shell which are mounted on slides and aged. The acetate peel method consists of 1) etching a cross-sectioned shell in HCL, 2) applying acetone and an acetate sheet to the cut surface, and 3) removing the acetate after the acetone has dried. Significant differences in age estimates between internal and external aging methods were noted in older age classes of specimens. A comparative evaluation of the various aging techniques is presented.

EFFECTS OF PREGNANCY ON FOOD AND WATER CONSUMPTION OF NORMOTENSIVE(WKY) AND SPONTANEOUSLY HYPERTENSIVE(SHR) RATS. V.A.Mutchler and J.L.Hart, Dept. of Biol., George Mason U. SHR rats have a higher food-induced water intake, water/food ratio (W/F), than do WKY rats, which may contribute to the elevated blood pressure (BP) of the SHR rats. During pregnancy, BP of SHR rats declines to normotensive levels. These studies determined if this BP drop in pregnancy was associated with a decrease in W/F. Food and water intake and systolic BP were measured in 6 WKY and 6 SHR rats before and at 1 wk intervals during pregnancy. The W/F( $2.23 \pm .1$ ) of the NPG SHR rats and BP( $274 \pm 8$ mmHg) were higher than those of the NPG WKY rats( $1.98 \pm .1$ )( $223 \pm 11$ mmHg). During pregnancy, the BP of WKY rats remained at NPG levels until the 3rd wk when it was  $183 \pm 10$ mmHg, while the W/F did not change. However, BP of SHR rats dropped to normotensive levels during the 1st wk and remained at this level; the W/F did not change during the 1st wk, but increased to  $2.82 \pm .2$  during the 2nd wk. These results suggest that factors other than a return to a normotensive pattern of food-induced water intake contribute to the SHR BP drop in preg.

ZOOGEOGRAPHY OF THE MUSSEL FAUNA IN THE NEW-KANAWHA RIVER. Richard J. Neves, Va. Coop. Fish. Res. Unit, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061. The New-Kanawha River is considered to be the oldest river system in North America, and yet the aquatic fauna in the upper drainage (New) is noticeably depauperate. Two kilometers below the Gauley River and New River confluence in West Virginia is Kanawha Falls, one of the highest falls (7.3 m) in the eastern U.S. During the Pliocene and Pleistocene, the Teays River, precursor to the New and Kanawha Rivers, apparently provided a major corridor for mussel dispersal both across the Atlantic Divide and to adjacent rivers. Below Kanawha Falls, 34 mussel species have been reported, whereas only 12 species occur above the Falls. The inception of Kanawha Falls apparently had a significant impact on the dispersal of many aquatic groups. This paper reviews available data on the mussel fauna and discusses the probable effects of glaciation and biological barriers on mussel distribution.

THE ROLE OF VISION AND OLFACTION IN PREY SELECTION BY THE SKINK SCINCELLA LATERALIS. Paul Nicoletto, Dept. of Biol., Va. Polytechnic Inst., Blacksburg, Va. 24061. The relative roles of vision and olfaction in prey selection by the lizard Scincella lateralis were investigated. The hypothesis tested was that S. lateralis would respond to prey (cockroach) using olfactory cues alone. Lizards were tested with four stimuli: visual, olfactory, concentrated olfactory, visual and olfactory, and a control. Responsiveness to these stimuli was measured by the rate of tongue flicking during a five minute test period. The rate of tongue flicking to the olfactory stimulus alone was not significantly different from the control, but the concentrated olfactory, visual, and visual and olfactory were. Thus, response was primarily motivated by visual cues, except when the olfactory stimulus was strong.

FOOD HABITS OF BROOK TROUT (SALVELINUS FONTINALIS) AND RAINBOW TROUT (SALMO GAIARDNERI) IN ALLOPATRIC AND SYMPATRIC POPULATIONS. W. H. Nilsen\* and L. A. Helfrich, Dept. of Fisheries & Wildl. Sci., Virginia Tech, Blacksburg, Va. 24061. Food habits of brook and rainbow trout in sympatric and allopatric populations were investigated to assess the extent to which trout species segregated into dietary niches. Collections of invertebrate drift, benthic invertebrates, and stomach contents of trout (110-210 mm) were made quarterly from August 1981 to June 1982 in three 200 m sections at Little Stony Creek, Giles County, Va. A total of 283 trout stomachs were examined. Stomach content analysis revealed that both species of trout were feeding more consistently on drifting than benthic invertebrates. Diet breadth of sympatric brook trout was generally narrower and exhibited greater seasonal variation than sympatric rainbow or allopatric brook and rainbow trout populations. Diet breadth of sympatric brook trout was narrowest when invertebrate resources were most abundant. Overlap values indicated that brook and rainbow trout utilized similar food resources. The lowest diet overlap values occurred when the density of benthic invertebrates was maximum and density of drifting invertebrates was high. These results suggest that diet segregation increases as food resources increase.

AN EVALUATION OF ROCK BASS HABITAT IN VIRGINIA STREAMS. Paul Pajak\*, Dept. of Fish. and Wildl. Sci., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 24061. Reliable evaluations of fish habitat are critical for impact assessment and mitigative management. However, no evaluation techniques have escaped the operational constraints imposed by the practical limits of sampling, variable correlation/interaction, and consideration of unique on-site features. The Fish and Wildlife Service has recently developed a Habitat Evaluation Procedure (HEP) which attempts to describe habitat suitability for a particular species using Habitat Suitability Index models (HSI's) for essential habitat parameters. This procedure incorporates both habitat quality and quantity into "Habitat Units" (HU's) for the species being evaluated. HSI's have not been field validated for most species. This investigation sought to test the assumption that rock bass HU's and standing stocks were positively correlated. Results of fish marking studies suggest that temporal variation in habitat utilization may significantly affect model predictions based on a single "critical" evaluation period.

INTERACTION OF THE ESTROUS CYCLE AND ADRENOCORTICAL ACTIVITY. Kathy Phillips\* and Margaret Till, Dept. of Biol., Old Dominion University, Norfolk, VA 23508. Contradictory results have been found in changes in adrenocortical function during the estrous cycle. A glucocorticoid binding protein of adrenal origin has been established and its activity appeared to be correlated with adrenocortical activity. The present study was undertaken to further delineate the role of the estrous cycle in adrenal function and its relationship to glucocorticoid binding activity (GBA). Female Sprague-Dawley rats (85-105 da) with normal estrous cycles were sacrificed at one of five designated stages: proestrus, early estrus, estrus, metestrus, and diestrus, and blood was collected. Adrenal glands were excised and incubated for 60 minutes. Media and plasma were analyzed for corticosterone content and media were assayed for GBA. Plasma corticosterone and secretion levels significantly greater during early estrus. GBA was significantly and negatively correlated with corticosterone secretion in vitro.



CHROMATOGRAPHIC ANALYSES OF POLYCYCLIC AROMATIC HYDROCARBONS IN TISSUE EXTRACTS OF CONTAMINATED OYSTER POPULATIONS. Charles A. Pittinger and Arthur L. Buikema, Jr., Ctr. for Environmental Studies, Va. Tech, Blacksburg, Va. 24061. Indigenous oysters from contaminated locations in the lower James and Elizabeth Rivers, Va., were analyzed for the presence of nonsubstituted polycyclic aromatic hydrocarbons (PAHs). Extracts of freeze-dried samples were prepared by soxhlet refluxing in methylene chloride. PAH fractions isolated by gel permeation chromatography (SX-8 Biobeads<sup>R</sup>, 5 ml methylene chloride/min, 5 psi) and concentrated by rotary evaporation were analyzed by gas chromatography (6 ft. SP-2100 column, FID, 30 ml N<sub>2</sub>/min, 100-285° C. at 5°/min). Concentrations of individual PAHs, including phenanthrene, fluoranthene, pyrene, chrysene, and benzo(a)pyrene, ranged from 0.027 to 2.9 ppm dry weight. Elizabeth River oysters contained greater numbers and higher concentrations of PAHs than did James River samples, presumably due to higher levels of fossil fuel contamination in the Elizabeth River.

THE REDISCOVERY OF CAPILLARIA SERPENTINA (NEMATODA:TRICHUROIDEA) FROM FRESH-WATER TURTLES IN VIRGINIA. Thomas R. Platt, Dept. of Biol., Univ. of Richmond, Richmond, Va. 23173. Capillaria serpentina Harwood, 1932, was found in the mucosa of the small and large intestine of the snapping turtle, Chelydra serpentina, and the mucosa of the small and large intestine of Chrysemys p. picta and Sternotherus odoratus, respectively, from Westhampton Lake in Richmond. Specimens compared favorably with previous descriptions of this nematode. Comparisons of worms from different hosts and locations within hosts, in the present study, revealed no differences that would warrant establishment of new taxa. Cap. serpentina is, therefore, the only species of the genus reported from chelonians. This is the third report of Cap. serpentina and is a new state record for Virginia. C. picta and S. odoratus are new host records. (Supported by a grant from the Univ. of Richmond Faculty Research Committee.)

A HISTOLOGICAL EVALUATION OF THE EFFECTS OF A NON-PROTEIN DIET ON THE MOUSE THYMUS. F.V. Sheffer\*, A.F. Conway, and P.L. Dementi, Dept. of Biol., Randolph-Macon Col., Ashland VA 23005. The effect of a protein deficient diet on the thymus was investigated by quantitative histology. Mice were maintained on normal or protein deficient diets for durations of 1, 2, 3, 4, or 5 days prior to age 35 days. At 35 days of age, mice were analyzed for thymus weight/gram body weight, % of thymus classified as cortex or medulla, and cells per field in the cortex or medulla. Control and experimental mice were compared using Student's t-test. Thymus weight was significantly reduced in experimental animals at all treatment times. Percent cortex was significantly reduced after 3, 4, and 5 days of treatment. Medullary cell density increased and cortical cell density decreased significantly over the treatment period.

TISSUE EXPRESSION OF SELECTED ENZYMES IN THE AMERICAN SHAD, Alosa sapidissima. Edward N. Sismour, Steve Ackerman, and Ray S. Birdsong, Dept. of Biol., Old Dominion Univ., Norfolk, Va. 23508. The American shad (Alosa sapidissima), an important commercial and sport fish, has been declining in abundance. Mature adults segregate into populations at the time of spawning when they migrate from the ocean into natal rivers. It is during this spawning migration that adults, especially females, are subjected to intense fishing pressure. Knowledge of the genetics of natural populations is recognized as an important foundation for effective species management; however, little is known about the genetics of shad. A study in our laboratory is currently examining the allelic distribution of two enzymes, malate dehydrogenase and non-specific esterase, in several tissues from freshwater and mixed fishery stocks. Results of the study may elucidate means of differentiating populations of the American shad, which may be used for examining influences of various selective pressures on population structure.

EARLY COLONIZATION PATTERNS OF PROTOZOANS AND DIATOMS. P.M. Stewart<sup>1</sup>, J.R. Pratt<sup>1\*</sup>, R.L. Lowe<sup>2\*</sup>, and J. Cairns, Jr.<sup>1</sup>, <sup>1</sup>Dept. of Biol. and Ctr. for Environmental Studies, Va. Polytechnic Inst. & St. Univ., Blacksburg, VA 24061 and <sup>2</sup>Dept. of Biol. Sci., Bowling Green St. Univ., Bowling Green, OH 43403. Colonization of artificial substrates by protozoans and diatoms was examined in 14 Michigan lakes and Pandapas Pond, Montgomery, Co., VA. Substrates were suspended in the littoral zone of all study sites and were harvested after 1, 3, 6, 15, and 21 days of exposure. The number of protozoan and diatom species were determined. Results were fitted to the MacArthur-Wilson model,  $S = S_{eq}(1 - e^{-Gt})$ . Estimates of colonization parameters were obtained by non-linear least squares regression. Equilibrium species numbers were similar, but not correlated, for both groups. The rate of species accrual was much greater for diatoms with equilibrium being attained in less than one day. Protozoan species equilibrium typically occurred in about 7 days. Although these organisms are of similar size and share similar habitats, colonization dynamics appear vastly different.

EFFECTS OF SPERM MOTILITY STIMULATORS ON CULTURED MOUSE EMBRYOS. Gordon K. Stokes, Steve Ackerman, and R. James Swanson, Andrology Laboratory, Dept. of Biol., Old Dominion Univ., Norfolk, Va. 23508. Infertility, especially in oligospermic males, may be due to defective sperm motility. Recently, several substances have been studied for their abilities to stimulate sperm motility and/or ova penetration. The present investigation analyzed the effects of the following sperm stimulators on the growth of cultured mouse preimplantation embryos: arginine, caffeine, cysteine, dibutyryl cAMP, and taurine. Kinetics of embryo development in vitro were analyzed from the two-cell stage to the blastocyst stage over 72 hours. Preliminary evidence indicates that all substances except arginine inhibit blastocyst formation. These studies may have implications for treatment of sperm used for either artificial insemination or in vitro fertilization.

POPULATION DYNAMICS OF BLACK AND TURKEY VULTURES. T. M. Sweeney and J. D. Fraser. Dept. of Fisheries and Wildlife Sciences, VPI & SU, Blacksburg, VA 24061. The number of roosting black vultures (Coragyps atratus) and turkey vultures (Cathartes aura) at a large roost near Radford, Virginia were counted as the birds left the roost at sunrise from 17 September 1981 to 31 March 1983. Counts were made at least three times monthly. Peak counts of roosting vultures were 498, 793 and 1107 on 21 September 1981, 5 December 1981 and 8 December 1982. The ratio of black to turkey vultures ranged from 1.6:1 on 10 December 1981 to 4.2:1 on 9 January 1983. Preliminary results suggest that annual fluctuations in numbers of roosting vultures are due to migration, changes in local food availability and use of seasonal roosts during the summer months.

STUDIES OF GLYCOSAMINOGLYCAN POPULATIONS IN CHICK LIMB DEVELOPMENT. Suzanne M. Thiem and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. White Leghorn chick embryos were harvested at various stages during early limb development and fixed in 4% paraformaldehyde-0.5% cetylpyridium chloride buffered at pH 7.2. Six micron paraffin sections were stained according to Alcian blue, PAS, or combined Alcian blue-PAS techniques in order to localize glycosaminoglycans (GAGs). PAS positive cell surfaces were found throughout the embryo. The extracellular material between the ectodermal epithelium and underlying mesenchyme was alcianophilic. Heavier deposits of alcianophilic material were observed beneath the apical ectodermal ridge and in the region of the zone of polarizing activity of the developing limb. Biochemical characterization of the GAGs isolated from limb buds at various stages of development are in progress.

CHARACTERIZATION OF A CORTICOSTERONE BINDING PROTEIN OF ADRENAL ORIGIN. Margaret Till, Dept. of Biol., Old Dominion Univ., Norfolk, VA 23508. Adrenal incubation media possess glucocorticoid binding activity (GBA). To investigate this phenomenon, adrenal glands were incubated for 15 minutes and subsequently for 60 minutes under basal or ACTH (200mU/ml)-stimulated conditions. Corticosterone secretion and GBA were significantly increased by ACTH. Gel electrophoresis of media showed the presence of seven proteins; three of which had GBA. Finally, adrenals were incubated as follows: basal conditions, ACTH (200mU/ml) stimulation, non-corticoid media components (NCMC) treatment, or ACTH and NCMC in combination. The NCMC was prepared by stripping media in which adrenals had been incubated of corticoids and adding this back to fresh media in concentrations equal to those following incubation. ACTH significantly increased corticosterone secretion; while the NCMC treatment did not significantly change corticosterone. In combination, ACTH failed to stimulate steroidogenesis, it appears that some non-steroid component blocked ACTH expression.

SPARTINA DECOMPOSITION BY INDIVIDUAL AND MIXED CULTURES OF SALT MARSH FUNGI. Albert P. Torzilli and George Andrykovitch, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Cultures containing sterilized Spartina alterniflora tissue were inoculated with single or mixed inocula of three salt marsh fungi, Buergenerula spartinae, Phaeosphaeria typharum and Pleospora pelagica. After 42 days of incubation at 25°C, Spartina decomposition was compared in experimental treatments vs. uninoculated controls by determining the amount of residual total fiber, hemicellulose, cellulose and lignin. A one-way analysis of variance of these results indicated that all individual and mixed fungal combinations significantly degraded the total fiber, hemicellulosic and cellulosic fractions of Spartina tissue with the exception that, by itself, P. typharum was unable to degrade cellulose. None of the individual or mixed inocula resulted in any lignin degradation. In most cases, mixed inocula resulted in a decreased ability of the competing fungal species to degrade the available Spartina substrate.

COMPARISON OF PROTOZOAN COLONIZATION OF POLYURETHANE AND POLYESTER UNITS IN TWO LENTIC ECOSYSTEMS. Michael R. Van Brunt and William H. Yongue, Jr., Dept. of Biol., Va. Polytechnic Inst., Blacksburg, Va. 24061. Artificial substrate units of polyurethane foam (PUF) and of polyester fabric (PEF) were suspended in the littoral zone of oligotrophic Mountain Lake and low pH, soft water Pandapas Pond during summer 1982. Hexahedral PUF units (5x6.3x7.6 cm) and cylindrical rolled PEF units (h=10.5, d=5.5 cm) were used. Periodically, 3 units of each type were collected and the number of protozoan species present was determined, also water quality tests were performed on selected samples. Tests for nitrates, chlorides, pH, hardness, alkalinity and dissolved oxygen indicate the water inside each substrate type is similar to the surrounding water in both systems. Of 16 possible fits (total species, flagellates, ciliates, sarcodines/per substrate/per system) to the MacArthur-Wilson colonization equation ( $S(t) = Seq(1 - e^{-gt})$ ) lack of fit ( $\alpha = .05$ ) was indicated in two cases, for flagellates on each substrate in Pandapas Pond. Between substrate types no significant differences in g-values were found, but two significant ( $\alpha = .05$ ) differences for Seq-values were found, for ciliates and sarcodines in Mt. Lake substrates. This data suggests that between these substrate types colonization parameters are similar and that in some situations the species composition may be different.

AN EVALUATION OF TECHNIQUES FOR KARYOTYPING MOUSE EMBRYOS. Allyson A. Van Steenbergen\* and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. Metaphase-arrested murine embryonic/fetal cells may be obtained following in utero exposure to Colcemid. Under conditions employed in our laboratory this method has not consistently produced adequate numbers of metaphase-arrested cells for subsequent chromosomal analysis. Histological analysis was performed to determine if 9-11 day embryos had adequate numbers of mitotically active cells. Mitotic cells were observed in the majority of developing organs at all three gestational ages. Embryonic cells were cultured in vitro in Eagle's Essential Medium supplemented with fetal calf serum and Colcemid for two to 24 hours to determine if sufficient numbers of metaphase-arrested cells could be obtained. Shorter culture periods (2 hrs) produced the largest number of metaphase-arrested cells from 9 and 10 day embryos whereas longer culture periods were better for 11 day embryos. We have concluded that the in vitro culture technique is the appropriate technique for future studies.

LIFE HISTORY ASPECTS OF THE REDLINE DARTER, ETHEOSTOMA RUFILINEATUM, IN THE NORTH FORK HOLSTON RIVER, VIRGINIA. James C. Widlak & Richard J. Neves, Va. Coop. Fish. Res. Unit, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061. Life history aspects of the redline darter were investigated between May 1981 and May 1982 in the North Fork Holston River, southwestern Virginia. Analysis of scale samples indicated that males grew slightly faster and reached a greater maximum length than females. Estimated annual survival for males and females was 0.44 and 0.33, respectively. Enumeration of stomach contents revealed that aquatic insect larvae were the major food items, dipterans predominating (67%-87%) at all times of the year. Peak feeding over a 24 hour period occurred from early to late afternoon (1600h-2000h). Sex ratios favored males throughout the year, attributable to differential survival and distribution. Age I individuals of both sexes greater than 42 mm TL were sexually mature. Ripe males were collected in March although spawning colors first appeared in December. Ova development began in late February, and spawning occurred in riffle areas from mid-May to mid-August.

AGGRESSIVE BEHAVIOR IN PEROMYSCUS LEUCOPUS AND P. MANICULATUS. Jerry O. Wolff & Siobhan M. O'Connor, Dept. of Biol., U.Va., Charlottesville, VA, 22901, Raymond D. Dueser, Dept. of Envi. Sciences, U.Va., Ch'ville, VA, 22901, & Mark H. Freeberg, Dept. of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824. Aggressive behavior was studied in two sympatric species of mice, Peromyscus leucopus and P. maniculatus, to test for intra- and interspecific territoriality. Same sex mice were paired in intra- and interspecific behavioral trials conducted in the home range of one of the animals. Resident animals won from 53% to 93% of the encounters, regardless of the species of their opponents. In intersexual trials conducted within and between species, aggression occurred in less than 10% of the trials, and the behaviors of residents and intruders did not differ significantly within or between species. Since males and females show site-specific dominance against same sex intruders of either species and tolerate those of the opposite sex, there is no evidence of species recognition.

COMPETITION BETWEEN PEROMYSCUS LEUCOPUS and P. MANICULATUS. Jerry O. Wolff, Dept. of Biol., Univ. of Virginia, Charlottesville, Va, 22901 & Raymond D. Dueser, Dept. of Environ. Sciences, Univ. of Virginia, Charlottesville, Va, 22901. A study was conducted to determine the ecological relationships between Peromyscus leucopus noveboracensis and P. maniculatus nubiterrae which co-occur in the montane forests of southwestern Virginia. These two species are morphologically, ecologically, and behaviorally similar and exhibit roughly synchronous population fluctuations. A stomach contents analysis showed that the two species have similar food habits and a vegetation analysis revealed no significant microhabitat differences. In reciprocal removal experiments, the remaining species colonized the habitat vacated by the removed species. In both cases, the remaining species exhibited higher population densities on treatment grids than on controls. Patterns of space use showed that males and females of both species maintain exclusive home ranges within each sex and appear to exhibit intra- and interspecific territoriality.

SPECIES RECOGNITION AND BEHAVIORAL ISOLATION IN PEROMYSCUS LEUCOPUS and P. MANICULATUS. Jerry O. Wolff and Cynthia Van Cleef, Dept of Biology, Univ. of Virginia, Charlottesville, VA. 22901. Wolff et al. (1983) have shown that Peromyscus leucopus and P. maniculatus are intra- and interspecifically territorial within each sex. Wolff et al. (in prep) have shown that males and females are amicable toward each other regardless of species, exhibiting no discernible differences in agonistic behavior. The objective of this research was to test for behavioral isolation and species recognition by conducting discrimination trials in the laboratory. In intersexual trials, males and females showed a preference for their own species, however, this was more pronounced in females than males. In intrasexual trials, males and females did not discriminate between species. We conclude that P. leucopus and P. maniculatus can distinguish between members of the opposite sex and are thus reproductively isolated. We were not however, able to demonstrate species recognition within sexes. The implications of this will be discussed.

IDENTIFICATION OF AGING RELATED CHANGES IN THE REPRODUCTIVE TRACTS OF CD-1 MICE. Monette W. Wood\* and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. Normally cycling female CD-1 mice were grouped according to age (3, 6, 9, 12+ months) and breeding history (nulliparous, multiparous). Within each age group females were sacrificed at different stages of the estrus cycle and their reproductive tracts (ovaries, oviducts, uterus, vagina) removed and weighed. Uterine tubes were flushed with physiological saline and the resulting irrigates used to determine the protein content of the intra-uterine tubal fluid (IUTF). Younger (3 month) nulliparous females showed the most distinctive weight change pattern (pre-estrus increase, post-estrus decline). In older nulliparous and multiparous females the relative reproductive tract weights did not show distinct changes during the estrus cycle. In recently bred females the relative reproductive tract weights continued to increase following estrus. The protein content of the IUTF in most age groups generally increased prior to estrus and then declined.

## Botany Section

COMPOSITION, STRUCTURE, AND DYNAMICS OF THE SPRUCE-FIR FOREST ON THE SUMMIT OF MOUNT ROGERS. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422 & S. L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554. The red spruce-Fraser fir (Picea rubens-Abies fraseri) forest on the summit of Mount Rogers in southwestern Virginia was intensively sampled to obtain data on composition, structure, and dynamics of vegetation of the northernmost extension of this southern Appalachian forest type. In addition, data were obtained on soil chemical and physical characteristics. Five tree species were present, but fir dominated all size classes with spruce the only important associate. Oxalis acetosella and Dryopteris campyloptera made up more than 95% of the total herb cover. The shrub stratum was poorly developed with just three species represented. This community is ecologically similar to other southern Appalachian spruce-fir forests.

NATURE TRAIL DEVELOPMENT IN THESE TIMES OF BUDGET CUTS AND VANDALISM. Marion C. Blois, Div. of Natl. and Appl. Sci., Northern Va. Cmnty. Col.-Manassas Campus, Manassas, Va. 22110. Budget cuts, higher rates of vandalism, and an increasing need for community support for higher education are all problems to be dealt with in all aspects of higher education. In developing and maintaining a Nature Trail, these issues must all be considered. In this presentation, measures to economize in trail development such as making one's own signs for identification of plant species, use of student help, and use of locally available materials will be discussed. Suggestions for minimizing vandalism such as placing identification signs on larger trees out of reach of teenagers and embedding cedar posts in the ground will be a second point of consideration. Finally, encouragement of community use of a nature trail to build community support and interest in college activities will be briefly discussed. Appropriate slides will illustrate implementation of these ideas on the Manassas Campus Nature Trail.

FLOWERING PLANT RECORDS FROM NORTHERN VIRGINIA. Ted R. Bradley, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Recent collections of flowering plants from northern Virginia have revealed several unusual records. Species spreading from cultivation and apparently new to the state are Anagallis linifolia (Primulaceae), Linaria maroccana (Scrophulariaceae), Euonymus fortunei (Celastraceae), and Hosta ventricosa (Liliaceae). Ulmus pumila (Ulmaceae) is reported for five new counties. Dipsacus laciniatus (Dipsacaceae) is reported from Loudoun Co. and Kochia scoparia (Chenopodiaceae) from four new counties. Polygonum perfoliatum (Polygonaceae) has reached Fairfax Co. from Maryland.

WOOD ANATOMY AND RELATIONSHIPS OF THE HAWAIIAN ENDEMIC GENUS NEOWAWRAEA (EUPHORBIACEAE). Dorthe Brandt\* & W. John Hayden, Dept. of Biology, Univ. of Richmond, Richmond, VA. 23173. Neowawraea was originally described as a distinct monotypic genus of the euphorbiaceous subfamily Phyllanthoideae. However, it has been generally treated as a species of the pantropical genus Drypetes. Three wood specimens of Neowawraea were studied for comparison with diverse genera of Phyllanthoideae. Anatomically, Neowawraea possesses simple perforations, thin-walled septate fibers, and poorly developed axial xylem parenchyma, whereas Drypetes has scalariform perforations, thick-walled non-septate fibers, and abundant diffuse and diffuse-in-aggregates axial xylem parenchyma. Thus, wood of Neowawraea is inconsistent with a close relationship with Drypetes. On the other hand, wood of Neowawraea conforms closely with the "Glochidion-type" wood structure of Phyllanthoideae; its closest relatives are thus to be found among genera such as Glochidion, Breynia, and Phyllanthus, rather than Drypetes.

Host Range and Germination of Branched Bromrape, Orobanch ramosa L., Texas Strain. Robert D. Coffin \* and Lytton J. Musselman \*, Dept. of Biol., Old Dominion Univ., Norfolk, Va. 23508 & Robert E. Eplee \*, USDA, APHIS-PPQ, Whiteville Methods Development Center, Whiteville, N.C. 28472. In this greenhouse test the Texas strain of Orobanch ramosa parasitized tomato, tobacco, eggplant, bell pepper, sunflower, celery and bell bean. Tomato and tobacco supported emergent growth of the parasite; only the underground stages were observed on the other hosts. Optimal germination in vitro was obtained by conditioning and germinating seed at 18°C. The effectiveness of strigol and four strigol analogs, GR-7, GR-24, GR-42 and GR-60 to induce germination was tested in vitro. Highest germination was obtained with GR-24, GR-7 and strigol. Of the three compounds, GR-24 induced greater germination. Concentrations of 0.01 ppm GR-24 and 1.0 ppm GR-7 induced 75.8 and 73.8 % germination respectively. Further increases in concentration did not significantly change the germination response. Due to regulatory considerations, field evaluations were not included in this study.

PRELIMINARY REPORT ON A LONG-TERM STUDY OF LOG DECAY IN THE GREAT DISMAL SWAMP. Frank P. Day, Jr., Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23508 The progress of decay, weight loss, and nutrient dynamics are being monitored in preweighed red maple logs which were set out fresh on four sites with different hydroperiods. Early results show that after one year logs on the wet maple-gum site decayed more rapidly (21% weight loss) than on the other sites (<11% weight loss). Possible explanations for the site differences are discussed. A preliminary conclusion is that under certain conditions, log decomposition may be much faster than previously estimated in the literature.

WOOD ANATOMY OF BETULA UBER, THE VIRGINIA ROUND-LEAF BIRCH. W. John Hayden, Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173, & Sheila M. Hayden.\* Wood structure of Betula uber is described as a contribution towards an understanding of the relationships of this rare and endangered birch. Salient features of Betula uber wood include: diffuse distribution of mostly solitary pores; vessel elements with scalariform perforation plates; minute, alternate intervacular pits; fiber-tracheids, often with gelatinous walls in the specimen examined; numerous, non-aggregate, homocellular procumbent rays; and predominantly diffuse apotracheal axial xylem parenchyma. Wood of Betula uber is typical of birches in general and matches in detail many of the diagnostic characteristics of birch woods belonging to series Costatae; however, it diverges strongly from woods of series Humiles. This conclusion is further supported by quantitative features of vessel element length, diameter, and frequency per cross-sectional area of wood surface. Relationship between Betula uber and species of series Costatae is thus favored over series Humiles.

RIPARIAN VEGETATION DISTRIBUTION RELATIVE TO FLUVIAL LANDFORMS AND FLOOD FREQUENCY ALONG THREE NORTHERN VIRGINIA STREAMS. Cliff R. Hupp\*, U.S. Geological Survey, 431 National Center, Reston, Va. 22092. Persistent patterns of woody vegetation distribution within the bottomland forest of three northern Virginia streams were identified and related to fluvial landforms above the stream channel. Vegetation patterns were investigated in valley bottoms of widely different sizes and related to channel geometry, streamflow characteristics, and sediment-size characteristics. Distinct vegetation patterns were found on four common fluvial geomorphic features: depositional bar, active-channel shelf, flood plain, and terrace. Vegetation data from these features were analyzed by binary discriminant and principal components analyses. Results and related field observations suggest that certain species are significantly associated with certain geomorphic features and that vegetation patterns develop as a result of particular hydrologic processes that shape each geomorphic feature rather than from sediment-size characteristics or depth to water table. Flood disturbance appears to be an important factor in maintaining the species patterns, which potentially might be used as indicators for particular hydrogeomorphic conditions.

VASCULAR FLORA OF EASTERN PRINCE WILLIAM COUNTY, VIRGINIA. Richard L. Keyser\*, Dept. of Biol., Col. of William & Mary, Williamsburg, Va. 23185. Prince William County east of Interstate 95 was visited 21 times in 1981-82 with 526 species of vascular plants recorded. Seventeen of these, including Celosia argentea, Cannabis sativa and Datura meteloides were strays or long-persistent from cultivation. Of the remaining 509 species, 119 (23%) were introduced but established. Despite much previous collecting, 96 of the 509 were new county records and Diervilla lonicera also a new Coastal Plain record. However 54 of the new species are introduced, reflecting the increasing disturbance of the area. The study area is twelve miles long and two to four wide, entirely within the Inner Coastal Plain, but dissected by six watersheds of the Potomac River, with a maximum relief of 222 feet. Tidal marshes had extensive emergent beds of Nuphar luteum, Rhus vernix and Dryopteris cristata were rare members of the bottomland community. Distinct spring, summer and fall weedy floras dominated disturbed areas. Deciduous woods and Pinus virginiana stands were other major habitats.

INTRASPECIFIC VARIATIONS IN PROTEIN COMPLEMENTS IN ISOLATES OF ENDOTHIA RADICALIS. J. A. Micales and R. J. Stipes, Dept. Plant Pathology and Physiology, Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061. The identification of isolates of Endothia radicalis (=E. fluens) is difficult because of the morphological similarity and shared host range of it with E. parasitica. Vertical slab gel polyacrylamide electrophoresis was used to distinguish six monoconidial isolates of E. radicalis from two representative monoconidial isolates of E. parasitica. The protein profiles of the E. radicalis isolates differed from those of E. parasitica both in the number and position of the protein bands. The banding patterns of Greek isolates of E. radicalis were quite similar to that of a European isolate of this fungus (CBS 240.54), while the protein profile of a New Zealand isolate was dissimilar to those of the other E. radicalis and E. parasitica isolates; this New Zealand isolate may represent a third species of Endothia. Vertical slab gel electrophoresis can be used to differentiate E. radicalis from E. parasitica, and to confirm or deny questionable identifications of isolates of these species.

TAXONOMIC IMPLICATIONS OF COMPARATIVE SENSITIVITIES OF ENDOTHIA PARASITICA AND E. GYROSA TO CAPTAN, CHLORTETRACYCLINE, DICHLORAN, FUNGISOL® AND VINCLOZOLIN. J. A. MICHALES and R. J. Stipes, Dept. Plant Pathology and Physiology, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The differentiation of Endothia parasitica from E. gyrosa based on their selective sensitivities to the fungitoxicants cycloheximide and Arbotect 20-S has been previously demonstrated. This work has been expanded to test for further differential sensitivities of these species to the following compounds: Fungisol, chlortetracycline, vinclozolin, captan and dichloran. These compounds are representative of the benzimidazole, tetracycline, substituted aromatic and dicarboximide classes of fungitoxicants, respectively. The fungitoxicants were incorporated into molten Difco potato-dextrose agar at increasing concentrations between 0.1 and 100 µg/ml. Mycelial plugs of five to ten monoconidial isolates each of E. parasitica and E. gyrosa were used as inoculum. After 8 days at 25°C, the radial growth of each colony and the percent growth inhibition based on the radial growth of nonamended control plates were determined. No significant differences in sensitivities to these compounds were observed. Endothia parasitica and E. gyrosa could not be differentiated by their growth responses to these compounds.



APPLICATIONS OF REMOTE SENSING DATA TO BOTANICAL AND GEOBOTANICAL STUDIES IN THE VIRGINIA PIEDMONT. N.M. Milton and M.D. Krohn, U.S. Geological Survey, Reston, Va 22092. The Virginia Piedmont constitutes an ideal site for testing remotely sensed data from a variety of sources for botanical and geobotanical work. Remote identification of plant species has already proved useful as an aid for lithologic mapping. Data sets currently available include Landsat MSS and TM, SMIRR data from the second Columbia flight, and several radar data sets of differing wavelengths. Computer processing is essential for enhancing subtle differences in spectral reflectance or backscatter. So far we have 1) enhanced winter Landsat MSS data to identify chestnut-oak communities, which are known to occur on certain lithologies; 2) identified two pine communities on a density-sliced and color-coded radar image; 3) distinguished three pine communities on Landsat TM data; 4) used SMIRR data to extract spectral curves for plant communities of known composition for use in the interpretation of data from other sources, particularly from future Landsat TM data.

POLLEN VECTORS OF WEST AFRICAN STRIGA HERMONTICA. L.J. Musselman, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23507, P.C. Matteson,\* Consortium for International Crop Protection, Berkeley, Ca. 94704, & S.J. Fortune,\* Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23507. Striga hermonthica is a root parasite that causes serious yield reduction in subsistence grain crops in sub-Saharan Africa. This parasite is strongly allogamous and reproduces exclusively from seed, but little information is available on factors involved in seed production. Floral visitors of S. hermonthica were collected from various sites in Upper Volta. These were examined for the presence of pollen using acetolysis and SEM microphotography. The results of this study indicate that S. hermonthica is visited by diverse insects and is probably not dependent on any single group for pollination, although considerations of floral morphology and length of mouthparts of insect visitors point to long tongued lepidopterans as likely being the most effective pollinators.

TREE RINGS IN THREE DIMENSIONS. Richard L. Phipps, U.S. Geological Survey, Reston, VA. 22092. Standard techniques of dendrochronology utilize measurements from one dimension (radius at breast height) of a three-dimensional subject (tree trunk). The shape of individual rings is near-paraboloidal, displaying a similarity in growth time trend between heights. Certain deviations in the expected growth trend appear explicable as functions of species and environmental conditions. The bulk of the annual growth increment in the upper part of the trunk takes place earlier in the growth season, and thus responds to different environmental conditions, than growth in the lower trunk. Measurements of rings at more than one height allow estimates of year-to-year height growth, and to seasonal variations in environmental conditions. Understanding interrelationships between heights is of potential value to interpreting the growth trend at breast height.

DISCRIMINATION OF VEGETATION PATTERNS IN WESTERN RANGELANDS BY MEANS OF REMOTE SENSING DATA. M.S. Power\*, N.M. Milton, M.D. Krohn\*, and M.H. Podwysocki\*, U.S. Geological Survey, Reston, VA 22092. Vegetation patterns, visible in remote sensing images, may provide information about soils, geomorphology, water availability, and mineralized areas. Remote sensing data acquired from radar and Landsat yield different geobotanical information. Radar images of the Escalante Desert in Utah enhance tonal features associated with discrete shrub communities, each growing on a different soil type. The tonal differences are related to shrub heights and canopy structure. Rangeland vegetation in the Pioneer Creek and Carpenter Creek drainages in Montana is closely tied to geomorphology. A Landsat compound ratio image enhances differences in spectral response that represent boundaries between vegetation communities growing on Tertiary lakebed deposits, lower slopes of alluvial fans, and upper slopes of alluvial fans. The Tertiary lakebed deposits may prove to be the best source for placer gold deposits.

SPRING TO SUMMER TRANSITIONS IN PHYTOPLANKTON POPULATIONS OF THE U.S. NORTH-EASTERN CONTINENTAL SHELF. D. A. Randolph\*, P. Zimba\*, L. Jugan\*, and H. G. Marshall. Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Phytoplankton results from 292 surface water samples, obtained during four 1982 cruises, indicated specific composition changes occurred from spring through fall across the northeastern shelf. Regional divisions of the shelf into north and south coastal, mid-shelf, and outer shelf stations showed each section to have a seasonally distinct assemblage, with a progressive successional pattern. Late spring dinoflagellates and small diatom dominants were generally replaced by large sized dinoflagellates and diatoms in summer, with a mixed group common in fall. Several ubiquitous species were also found over the entire shelf. Regionally, dinoflagellates and small sized diatoms predominated near shore and along the outer shelf, with larger species abundant at mid-shelf. Cryptomonads, cyanophyceans, euglenoids, and an ultraplankton component were also common over the shelf. Supported in part by NOAA/NEMP Ocean Pulse.

STEM ONTOGENY IN CHAMAESYCE HIRTA (EUPHORBIACEAE). Marilyn Rosengarten\* & W. John Hayden, Dept. of Biology, Univ. of Richmond, Richmond, Va. 23173. Chamaesyce hirta is a weedy tropical species with a growth habit somewhat intermediate between erect and densely matted prostrate species in the genus. Stem ontogeny was studied from serial paraffin sections of early developmental stages of seedlings. As in all species of Chamaesyce, the epicotyl produces only a single pair of leaves and develops no further; growth resumes through initiation of lateral branch axes, the first pair of which are axillary to the cotyledons. The course of leaf traces, sites of subsequent lateral axis initiation, and vascularization of lateral axes are described in detail through various developmental stages. These ontogenetic data are significant in assessing Roeper's hypothesis concerning the phylogenetic derivation of Chamaesyce from Euphorbia.

THE CURRENT STATUS OF VIRGINIA ROUND-LEAF BIRCH, BETULA UBER. T. L. Sharik, D. M. Porter, P. P. Feret, R. E. Kreh, Depts. of Biology and Forestry, Va. Polytechnic Inst., Blacksburg, Va. 24061 and R. H. Ford, Southwest Virginia Community College, Richlands, Va. 24641. From 1975 to early 1982 the only known wild population of Betula uber, located in southwest Virginia, declined from 40 to 12 individuals. Clearing of forests, removal of litter, and scarification of soil in the winter of 1981-82 adjacent to the remaining reproductively mature trees resulted in the germination and establishment of 80 seedlings in the summer of 1982. This treatment, designed to simulate natural disturbance, indicated that B. uber is capable of reproducing itself in the wild given the proper environmental conditions. The concurrent production of approximately 100 seedlings in the greenhouse from open-pollinated seed of B. uber will be used to establish several experimental populations on public lands within the next year.

HOLOCENE (8000-6000 B.P.) FRUITS AND SEEDS FROM MACON COUNTY, ALABAMA. Donna L. Shipp, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Holocene clays along Uphapee Creek were sampled for macroflora and pollen analyses on a U. S. Geological Survey sponsored field trip. One deposit was particularly rich in seed and fruit remains. Radiocarbon dating indicates an age of 6360 ± 110 y B.P. (U.S. Geological Survey Radiocarbon-41, Reston, Va.). Seeds and fruits were isolated and examined with light and scanning electron microscopy. Seed and fruit genera found include Betula, Rhynchospora, Fagus, Panicum, Ceratophyllum, Vitis, Parthenocissus, Quercus, Carya, Pinus, Strophostyles, Fraxinus, Liriodendron and Xanthium. Among these genera are aquatics and understory plants that have not been found in leaf and pollen remains. These genera indicate a flora similar to the flora present in the region today.

MICROENVIRONMENTAL PARAMETERS OF FIVE UPLAND FOREST TYPES IN THE MOUNTAIN LAKE AREA OF SOUTHWESTERN VIRGINIA. S. L. Stephenson, Dept. of Biol., Fairmont State College, Fairmont, W. Va. 26554, and A. A. Normandy\*, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Microenvironmental parameters of five upland forest types in the Mountain Lake area of southwestern Virginia were examined in conjunction with an investigation of the distribution and ecology of Myxomycetes in these same communities. Topographic parameters were determined and quantitative data on the structure and composition of the vegetation were obtained for a 0.1 ha study area at each site. Soil temperature, air temperature, and soil moisture were monitored during the period of June 21 to August 14, 1982. Soils associated with each site were analyzed for texture, organic matter, pH, Ca, P, K, Mg, Zn, Mn,  $\text{NO}_3\text{-N}$ , and soluble salts. Other microenvironmental parameters measured or determined included light intensity, bark pH, and pH of the litter layer. The results of this study are described and discussed. (Supported by a Univ. of Va. post-doctoral fellowship and a undergraduate research scholarship.)

DIATOM COMMUNITY ANALYSIS OF GRAVEL PIT PONDS. P.M. Stewart, Dept. of Biol., Va. Polytechnic Inst. & St. Univ., Blacksburg, VA 24061 and M.C. Miller\*, Dept. of Biol. Sci., Univ. Cincinnati, Cincinnati, OH 45221. This study was designed to determine diatom community structure of gravel pit ponds and to examine environmental parameters that affect diatom assemblages. Samplers were placed in 33 gravel pit ponds near Cincinnati, OH. After a three week colonization period, 250 diatom taxa were recorded, with 20-73 species/pond. Various null hypotheses were tested for possible explanations of diatom community composition. The number of species in a pond, the number of ponds in which a species was found, and the number of species shared between ponds were compared to neutral models and found to not be random. The MacArthur-Wilson model was rejected as a possible explanation of the number of species found in a pond. No distance effect on community similarity was observed. Correlational procedures utilized suggested a possible relationship between several diversity indices and environmental parameters, including substrate and productivity.

THE MIRAGE OF PLANT HEALTH. R. Jay Stipes and Jessie A. Micales, Dept. of Plant Pathology & Physiology, Va. Polytech. Inst. & State Univ., Blacksburg, VA 24061

After the query, "What is this plant?," probably comes the next most often asked question, "What is wrong with my plant?" The charge given to plant pathologists is to address the latter query. To understand the parameters of "disease," one must have delimited those of "ease" or "health," since disease is considered to be an unhealthy state. To understand health, then, one must have a comprehensive grasp of the "normal" or "perfect" physiology, anatomy, morphology, ecology and other aspects of the patient in question. Since there is no plant for which all biochemical constituents and physiological reactions and their normal parameters are comprehensively known, then we must be using arbitrary absolutes and flexible parameters when we indicate that a plant is healthy or diseased. Perhaps in our experimentation and other considerations, we should refer to healthy plants as "apparently healthy" or simply as "control" plants. These concepts are especially germane to our diagnoses and measurements, for example, of abiotic stresses and disease complexes. In summary, absolute health and disease are on a continuum, with nebulous lines of demarcation from a physiological perspective, but not from an economic one!

RADIAL GROWTH RESPONSES OF TWO TREE SPECIES TO CLIMATE IN NORTHERN VIRGINIA. J. C. Whiton\*, U. S. Geol. Survey, Reston, Va. 22092. Annual ring widths of Quercus alba and Liriodendron tulipifera were used to analyze monthly response of radial tree growth to temperature and precipitation. Each species was sampled from two mesic sites: on soil underlain by limestone conglomerate, and on soil derived from metamorphosed schist. Monthly responses to climate were derived by multiple regression of standardized tree ring widths with principal components of climate. Liriodendron from the limestone site seems more responsive to temperature than to precipitation. Radial growth was correlated with low temperatures in May and July, and with high precipitation in July. Thus, for both sites, Quercus alba and Liriodendron may be most valuable for reconstruction of late spring and early summer climate.

LICHEN SECONDARY COMPOUND INHIBITION OF LICHEN ASCOSPORE GERMINATION. John C. Whiton\* and James D. Lawrey, Dept. of Biol., George Mason Univ., Fairfax, Va. 22030. Germination responses of ascospores of three lichenized fungi, Cladonia cristatella, Graphis scripta and Caloplaca citrinia, and the nonlichenized ascomycete Sordaria fimicola, were observed in the presence of pure lichen acids. Acetone solutions of lichen acid at a concentration of  $2.7 \times 10^{-3}$  M were poured onto buffered agar ranging in pH from 4 to 7, the acetone was evaporated and spores deposited on the agar. Treatment plates received either evernic or stictic or vulpinic acid or atranorin. Control spores were not exposed to lichen acid. Evernic and vulpinic acid usually reduced or completely inhibited germination. Stictic acid and atranorin were usually nontoxic. Lichen acid toxicity was independent of pH. There was no apparent differential toxicity toward the nonlichenized Sordaria or toward crustose species. Lichen acids have allelopathic potential, thus, they may affect the structure and development of natural plant communities.

RESPONSES OF TERRESTRIAL MOSSES TO  $SO_2$  AND DESICCATION. William E. Winner, Dept. of Plant Pathol. & Physiol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Gas exchange experiments were used to define the photosynthetic responses of 3 common feather moss species to both desiccation and  $SO_2$ . Pleurozium schreberi, Hylocomium splendens, and Ptilium crista-castrensis were studied. Experiments included simultaneous measurements of desiccation, net photosynthesis, and  $SO_2$  uptake. P. schreberi seemed the most sensitive species to desiccation and  $SO_2$ , both alone and in combination. The immediate effects of  $SO_2$  upon photosynthesis of fully hydrated and partially dried mosses were similar. Only mosses fumigated in the fully hydrated condition retained photosynthetic impairment following a 24 h recovery period. This probably is related to the larger amounts of  $SO_2$  absorbed by fully hydrated plants. Thus  $SO_2$  resistance of mosses changes as they desiccate.

CHANGES IN THE VESSEL ANATOMY OF FLOOD-DAMAGED TREES. Thomas M. Yanosky\*, U. S. Geol. Survey, Reston, Va. 22092. Concentric bands of abnormally large vessels were detected in the latewood of ash trees (Fraxinus americana L. and F. pennsylvanica Marsh.) sampled along the Potomac River near Washington, D.C. Tangential diameters of vessels ranged from 60-160  $\mu m$ , compared to 30-60  $\mu m$  for typical latewood vessels. Tyloses were generally apparent. Within a particular annual ring, the largest and most closely spaced vessels formed near the apex, and became smaller and diffuse basipetally. In some trees, vessels developed only near apices. It is hypothesized that abnormal vessels develop when flood-stripped crowns produce a second crop of leaves. Supporting evidence is that vessels formed only during years of known flooding, and only if trees had been totally submerged. Additionally, trees experimentally defoliated formed similar growth patterns upon refoliation. Variations in the size and spacing of vessels at different stem heights suggest that development is controlled in large part by the polar movement of growth regulators along a diminishing gradient from expanding buds and leaves.

EVIDENCE OF HIGH STREAMFLOW LEVELS FROM THE LATEWOOD FIBERS OF FLOOD-PLAIN TREES. Thomas M. Yanosky\*, U. S. Geol. Survey, Reston, Va. 22092. Changes in the transverse dimensions of latewood fibers were studied in growth rings of ash trees (Fraxinus americana L. and F. pennsylvanica Marsh.) collected along the Potomac River near Washington, D. C. Concentric bands of fibers with atypically large lumens and thin walls were commonly detected in trees growing near the low-water channel. Streamflow records indicate that roots of most trees with these "white rings" were flooded during the latewood-growth interval. Trees apparently were not damaged and a concomitant reduction in water stress seems to have accelerated the rate of radial growth. The intra-annual position of anomalous fibers generally corresponded to the time of increased streamflow within the estimated interval of latewood growth. For example, white rings in the outer latewood coincided with high flows in late July or August. Trees occasionally formed anomalous fibers even though roots were not flooded, although associated discharges were significantly greater than the corresponding value of the 50-year monthly average. These studies may provide insights into the rate and timing of radial growth and might have applications for streamflow-reconstruction techniques.

A COMPARISON OF CHLOROPHYLL A EXTRACTION EFFICIENCY FOR PHYTOPLANKTON. P. V. Zimba\*, W. Dunstan, and H. G. Marshall. Departments of Biological Sciences and Oceanography, Old Dominion University, Norfolk, Va. 23508.

Chlorophyll a concentration was determined using two extractants - DMSO: Acetone (4:6 v/v) and aqueous acetone (90%). The method of Burnison (1980) was modified, eliminating the necessity of two filtrations. A Turner Designs fluorometer was used for the chlorophyll measurement on six phytoplankton cultures that included both fresh water and marine species. The cultures consisted of a cyanophycean, three chlorophyceans, a diatom, and a diatom mixture. In all cases the DMSO:Acetone extraction procedure was at least as efficient as the use of aqueous acetone. When DMSO:Acetone was used to extract Skeletonema costatum and two chlorophyceans (Volvox aureus and Carteria sp.), higher chlorophyll a values were obtained ( $p=0.05$ ). The use of the DMSO: Acetone extraction on marine cultures has not been reported previously in the literature.

COMPARISON OF LEAF CHLOROPLAST ULTRASTRUCTURE IN  $C_3$  and  $C_4$  MONOCOTS. P. V. Zimba\*, V. Wang\*, and K. K. Nesius. Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Avena sativa ( $C_3$ ) and Zea mays ( $C_4$ ) chloroplast thin sections were examined by transmission electron microscopy for proportion of constituent stroma and lamellae. Avena mesophyll chloroplasts consisted of 65% lamella and 35% stroma. Zea mesophyll chloroplasts located 7 cells towards the leaf margin consisted of 86% lamella and 14% stroma; whereas, mesophyll chloroplasts adjacent to the bundle sheath consisted of 78% lamella and 22% stroma. The bundle sheath chloroplasts contained 13% lamella and 87% stroma.

## Chemistry Section

THE DEPENDENCE OF LEACHING OF CATIONS FROM SEDIMENTARY ROCKS ON PH; AN ACID RAIN ANALYSIS. Daniel Armstrong, Robert T. Grauer Jr., David S. Knitter, Michael A. Pleva, Scott S. Prysi, James K. Shillington, Richard W. Young, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. For the purposes of our research both natural and synthetic acid rain. Samples of various sedimentary rocks of known mass were introduced into a predetermined volume of the acid rain. Both the cation leaching (measured in terms of dissolved solids) and the pH variation were measured over time. Current data suggests that the amount of cation leaching is determined by the pH of the acid rain medium and on the type of rock introduced.

INVESTIGATION OF SOLVENT PAIR RATIOS DURING PROGRESSION ALONG REVERSED-PHASE THIN LAYER CHROMATOGRAPHIC PLATES FOR THE PURPOSE OF FRACTIONATING HOMOPOLYMERS. Daniel W. Armstrong, D. James Bailey III, John W. Miller III, James K. Shillington, Robert B. Tucker, Jr., Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. The composition change of the mobile phase along the length of the chromatogram allows one to fractionate polystyrene homopolymers by reversed-phase thin layer chromatography. The adsorption of the more hydrophobic component of the solvent pair to the hydrophobic stationary phase causes this gradient change. If the composition change can be calculated as the solvent pair travels along the chromatogram, the best solvent ratio for the fractionation of polymers of particular molecular weights can be found.

THE STRUCTURAL HYPOTHESIS OF CANCER: A ROLE FOR THE CELL MEMBRANE IN BIO-CHEMICAL EQUILIBRIUM. P. G. Barber, Department of Natural Sciences, Longwood College, Farmville, Virginia 23901. A hypothesis is presented and current literature cited to suggest that cell membranes have a major role in the regulation of cell function and the maintenance of cellular equilibrium, which complements the role of the genetic material. Small, active molecules such as superoxide ion have an important function in this regulation by modifying membrane behavior. The production of proteins completes the feed-back loop by providing a further means of communication between the cell wall, the cell nucleus, and other organelles.

2-ALKYLIDENE-1,3-CYCLOPENTANEDIONES: VERSATILE SYNTHETIC INTERMEDIATES. William H. Bunnelle\*, Dept. of Chem., Col. of William and Mary, Williamsburg, Va. 23185. Sulfenylation-oxidative elimination of 2-alkyl-1,3-cyclopentanediones provides a mild and simple route to 2-alkylidene-1,3-cyclopentanediones, a heretofore elusive class of compounds. Their high reactivity towards carbon-carbon bond-forming reactions, notably Diels-Alder additions, coupled with the synthetic flexibility of the cyclopentanedione moiety fortell a promise of extraordinary synthetic utility for these compounds. The utility of 2-phenylthio-1,3-cyclopentanedione as a synthon for this system further extends the adaptability of this method.

STUDIES ON EXTRACTABLE CONSTITUENTS OF FOMES ROBINIAE. Peyton Frost Burnett\* and James B. Patrick, John Baker Daffin Dept. of Chemistry, Mary Baldwin Coll., Staunton, Va. 24401. Fomes robiniae (Murr.) Sacc. et D. Sacc. (Polyporaceae) is a woody bracket fungus occurring abundantly in the central Shenandoah Valley. Extraction of the dried and pulverized fungus with several solvents has yielded a variety of products after pH fractionation of the extracts. The acetone extract yields a significant quantity of a neutral fraction composed predominantly of two components separable by flash chromatography. We report herein the results of preliminary characterization of these two components by nuclear magnetic resonance, infrared, and ultraviolet spectrometry and wet chemical tests.

POLYMERIC ANTIBIOTICS OF GRAMICIDIN-S. Susan L. Carstens and Patrick G. Barber, Department of Natural Sciences, Longwood College, Farmville, Virginia 23901. Gramicidin-S is a cyclic decapeptide antibiotic that contains two amine groups on the ornithine amino acid residues. These were used to prepare a series of polymers by condensation with several diacyl chlorides of increasing chain length. The resulting polymers retained antibiotic behavior against gram positive bacteria, and this retention was in proportion to the amount of gramicidin-S incorporated into the polymer. These results are in conflict with those reported in the literature which indicate that the antibiotic activity of gramicidin-S is lost upon acylating the ornithine amine groups.

pH-INDUCED CONFORMATIONAL TRANSITION OF POLY(ITACONIC ACID-CO-STYRENE). C. Y. Chung and R. M. Ottenbrite, Dept. of Chem., Virginia Commonwealth Univ., Richmond, Va. 23284. A highly regular structure of itaconic acid-styrene copolymer was prepared by free radical polymerization and separated into two molecular weight fractions 1,000-10,000 and 10,000-30,000. This copolymer was characterized by FT-IR, elemental analysis and FT-C13 NMR. These analysis indicate that the polymer has an alternating head-to-tail structure in both molecular weight fractions. The effects of counterion binding and ionic strength of lithium, sodium and TMA ions on the pH-induced conformational transition was evaluated by potentiometric titrations and viscometric titrations. The order of ionic binding was found to be  $\text{Li}^+ > \text{Na}^+ > \text{TMA}^+$  in both aqueous and salt solutions. The effect of ionic strength of the counterion (salt effect) has a predominant influence in the case of lithium and sodium ions, but only a small role in the case of TMA ions. The free energy change ( $\Delta G^\circ$ ) was evaluated and correlated with the conformational change for each transition. The low molecular weight fraction appears to be more sensitive to site binding on the polymer and to ionic strength of the solution than the higher molecular weight fraction. Viscosity data indicates that molecular expansion during the titration process for the high MW fraction is much greater than in the low MW fraction.

AN EASY, GENERAL SYNTHESIS OF ARYL SULFONES. Donald W. Clary,\* Herbert J. Sipe, Jr., and Samuel B. White,\* Department of Chemistry, Hampden-Sydney College, Hampden-Sydney, VA 23943. An improved synthesis of aryl sulfones is reported. This improved synthesis, a modification of that reported by Graybill [cf. J. Org. Chem., 1967, 32, 2931], consists of adding phosphorous pentoxide to the polyphosphoric acid reaction medium and to the appropriate sulfonic acid reagent. Syntheses of phenyl-tolyl sulfone, diphenyl sulfone, biphenyl-phenyl sulfone, and ditolyl sulfone by this modified procedure resulted in substantial increases in yield over those reported by Graybill.

SELECTIVITY ENHANCEMENT STUDIES OF POTENTIOMETRIC BACTERIAL ELECTRODES. Carolyn A. Corcoran\* and Robert K. Kobos, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va. 23284. The selectivity of a previously reported bacterial arginine electrode has been greatly enhanced, with no loss of response to L-arginine. The arginine electrode is a potentiometric sensor which consists of intact bacterial cells (Streptococcus faecium) coupled with an ammonia gas-sensing electrode. This electrode has been shown to exhibit a near-Nernstian response to L-arginine in the concentration range of  $4.0 \times 10^{-5}$  M to  $1.5 \times 10^{-3}$  M. However, glutamine is a serious interference if it is present in the sample solution, thereby limiting the application of the sensor in biological fluids. In this study, it was found that the response to glutamine was negligible initially but increased daily, possibly due to the presence of a contaminant in the bacterial layer of the electrode. It was shown that using  $1.0 \times 10^{-3}$  M sodium azide in the working buffer and storing the electrode at 0°C effectively maintains the initial low response to glutamine in the concentration range of  $4.0 \times 10^{-5}$  M to  $1.5 \times 10^{-3}$  M, without reducing the response to L-arginine. When this procedure is followed, the sensor can be used to measure L-arginine in the presence of up to  $1 \times 10^{-3}$  M glutamine.

AN APPLICATION OF THE BENEDETTI-PICKLER EQUATION IN THE SAMPLING OF COMPLEX MIXTURES FOR CHEMICAL ANALYSIS. John J. Delany, III, M. A. Pleva, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. An area of analytical chemistry of considerable importance is sampling and sampling errors. Sampling is usually not considered in analytical chemistry courses because of its complexity. This work demonstrates the problems of sampling and their solution using the Benedetti-Pickler and hopefully facilitates the understanding of the sampling process.

MECHANISM FOR THE AQUEOUS DECOMPOSITION OF 1-PIPERIDINOCYCLOHEXANE CARBONITRILE. M. P. DiFazio\* and W. H. Soine, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298. The presence of piperidinocyclohexanecarbonitrile (PCC) in illicit phen-cyclidine is of toxicological importance because it decomposes to release cyanide. This study was directed toward determining the mechanism by which cyanide was released. PCC was observed to undergo pseudo first order decomposition in buffered solution and the rate of decomposition was found to be dependent on the pH of the buffer. Initially, the rate of decomposition increased from pH 2 to 5.6 where a maxima was reached. The rate then decreased until it reached a minima at pH 8.3 followed by a second increase in rate of decomposition to pH 13. These results indicate there is both an acid catalyzed and base catalyzed mechanism for the release of cyanide and suggests that PCC decomposes through both an imine and enamine intermediate (Supported by the Grants-in-Aid Program for Faculty at Virginia Commonwealth University).

THE EFFECTS OF *TRANS* FATTY ACIDS ON  $\Delta 5$  FATTY ACYL DESATURASE ACTIVITY IN HUMAN SKIN FIBROBLASTS. Mark A. Doloresco\*, Dept. of Chem., Old Dominion Univ., Norfolk, VA 23508, and Miriam D. Rosenthal, Dept. of Biochem., Eastern Va. Med. School, Norfolk, VA 23501. Fatty acyl  $\Delta 5$  desaturase converts eicosatrienoate (20:3) to arachidonate. Dietary *trans* fatty acids alter essential fatty acid metabolism *in vivo*. We investigated the effects of *trans* fatty acids on  $\Delta 5$  desaturation. Human skin fibroblasts were preincubated for 2h with *trans*-vaccenate (11t 18:1), elaidate (9t 18:1) or linoelaidate (9t 12t 18:2).  $2.5\mu\text{M} [^{14}\text{C}]$ Eicosatrienoate was then added. After 6h the cells were harvested and their lipids extracted.  $[^{14}\text{C}]$ Fatty acid methyl esters were prepared, and analyzed by radio-gas chromatography. Control cells desaturated 58% of the incorporated  $[^{14}\text{C}]$ 20:3. Desaturation was 20%, 33%, and 46% for cells given  $40\mu\text{M}$  elaidate, linoelaidate and *trans*-vaccenate respectively. Elaidate was as inhibitory as arachidonate. Thus inhibition by *trans* 18:1 isomers is influenced by the position of the double bond. (Supported in part by NIH Grant HL-23658.)

SYNTHESIS OF 5-<sup>3</sup>H-1,2,3-BENZENETRIOL (PYROGALLOL). D. M. Dulik\* and W. H. Soine, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298. In order to facilitate metabolic studies of pyrogallol (1,2,3-benzenetriol, PY), it was necessary to radiolabel PY with tritium in a chemically stable position. Model reactions using deuterium resulted in the formation of 4,6-<sup>2</sup>H<sub>2</sub>-PY under both acid and base catalyzed conditions. However, under simulated physiological conditions, it was observed that the label underwent facile exchange. Alternatively, 5-<sup>2</sup>H-PY was prepared via a two step synthesis. Transmetalation of 3,4,5-trimethoxybromobenzene (I) with n-butyllithium in dry hexanes at -70 C to -30 C followed by quenching with excess D<sub>2</sub>O gave 5-<sup>2</sup>H-1,2,3-trimethoxybenzene (II). O-demethylation of (II) with BBr<sub>3</sub> and HBr in CH<sub>3</sub>COOH gave 5-<sup>2</sup>H-PY (III) in 30% overall yield. 5-<sup>2</sup>H-PY was found to be stable to exchange under physiological conditions. This method was employed to prepare 5-<sup>3</sup>H-PY with specific activity of 7.6 mCi/mmol and of suitable purity for use in *in vivo* metabolism studies.

CHEMISTRY AND THE CONSERVATION OF ARTIFACTS IN THE SOVIET UNION. Vera B. Espinola, Ethnographic Objects Conservator, 3634 Camelot Drive, Annandale, Va. 22003. A report is given of research and analytical chemistry as it is utilized in the service of conservation at the All Union Scientific and Research Institute for Restoration (VNIIR) in Moscow. Solvents and adhesives used in the major restoration centers of Moscow and Leningrad are fairly standardized with a preference for natural organic adhesives in the conservation of icons and textiles. Synthetic polymers are approached cautiously and observed in accelerated aging tests to determine if they conform to the principle of reversibility. The use of ftorlon and ftoroplast, a recently developed polytetrafluoroethylene product is discussed. A brief account is given of health hazards in the handling of some conservation materials. (IREX grant, USSR, 1980)



PREPARATION AND STUDY OF ELECTRICAL CONDUCTIVITY OF A HETEROAROMATIC LADDER POLYMER: BBL. Patricia Etienne\* and George W. Mushrush, George Mason Univ., Fairfax, VA 22030 and David C. Weber,\* Naval Research Laboratory, Washington, DC 20375. Synthetic organic metals have recently been the subject of extensive research efforts. Polyacetylene,  $(CH)_x$ , is the simplest conjugated polymer with a planar backbone. Doping enhances the electrical conductivity of  $(CH)_x$  by twelve (12) order of magnitude. Graphite, also a planar material, exhibits intrinsic metal-like conductivity that can be increased by doping (intercalation).

Ladder polymers such as benzimidazobenzophenanthroline (BBL) have structurally rigid, planar geometry. Because BBL incorporates the conjugated planar backbone structure of polyacetylene with an extended ring network similar to graphite, we are presently studying the effects of chemical doping on the electrical conductivity of BBL.

The BBL ladder polymer was synthesized by condensation polymerization of 1,4,5,8-Naphthalenetetracarboxylic acid (NTCA) and 1,2,4,5-Tetraaminobenzene tetrahydrochloride (TAB-4HCl). Films were prepared by precipitation from methanesulfonic acid and vacuum filtration on a glass frit. Chemical doping procedures and electrical conductivity measurements will be discussed.

**A HALF-CENTURY OF CHEMISTRY: PERSONAL EXPERIENCES AND VIEWPOINTS.** Hyman I. Feinstein\*, 10411 Forest Ave., Fairfax, VA 22030.

The story of one chemist starting his career at the beginning of the great depression will be traced through a teaching apprenticeship, government service, and back to teaching before retirement. Chemists in academe and government who exerted an important influence on this career, practical problems and the thought processes that helped solve them, research and publications, peer and referee review, professional and subprofessional teaching, the role of descriptive and theoretical chemistry, and serendipity, will all be frankly discussed as time will allow.

RECENT SYNTHETIC ADVANCES IN THE ORGANOMETALLIC CHEMISTRY OF CHLOROCYCLOTRIPHOSPHAZENES. Paul J. Harris and Logan A. Jackson\*, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The organometallic chemistry of cyclic chlorophosphazenes has been a subject of intense study in recent years. These reactions are found to proceed via a variety of different pathways including metal-halogen exchange and ring cleavage. Only recently have reactions that proceed via substitution of halogen been observed. The reactions of organotitanium reagents are found to yield monoalkylated phosphazenes whereas organoaluminum reagents are found to yield a variety of highly alkylated phosphazene compounds.

The mechanistic aspects of these reactions will be discussed along with the spectroscopic characterization of the products.

INVESTIGATION OF THE EFFECT OF A SHORTENED INCUBATION PERIOD ON THE RELIABILITY OF THE RADIOIMMUNOASSAY FOR CORTICOTROPIN. Anne R. Keller\*, Dept. of Biochem., McGill Univ., Montreal, Quebec, Canada. The Radioimmunoassay (RIA) method originally developed by Berson and Yalow for determining corticotropin (ACTH) levels employs a six day incubation in order to achieve maximum sensitivity. Workers using shorter incubations have not studied the extent of change in sensitivity. This paper compares the sensitivity of the ACTH assay for standard curves run for 1/4 to 2 hours at 25° C with curves run for 3-7 days at 4° C. Precision was shown to be equal in the two methods and sensitivity was more than adequate for the analysis of the hormone present in cultured cell preparations which were the subject of our investigations. It was concluded that the use of a shortened incubation period is valid and that the advantages in time saved more than offset the decrease in sensitivity observed.

REACTIONS OF Mo(VI) SCHIFF BASE COMPLEXES WITH ETHYLDIPHENYLPHOSPHINE. James T. Lyon, III and Joseph Topich, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284. The reaction of ethyldiphenylphosphine with a number of cis-dioxomolybdenum(VI) coordination complexes are described. These complexes incorporate tridentate Schiff base ligands obtained from the condensation of 5-X-salicylaldehyde (X = Cl, Br, H, CH<sub>3</sub>O) with o-aminobenzenethiol or 2-aminoethanethiol. Oxo-molybdenum(IV) Schiff base complexes were observed as products of the reaction of these Mo(VI) complexes with  $\text{PEt}\phi_2$ . The kinetics for these reactions were followed spectrophotometrically and the applicable rate law is  $-d[\text{MoO}_2\text{L}]/dt = k_1[\text{MoO}_2\text{L}][\text{PEt}\phi_2]$ . The  $k_1$ 's are shown to vary systematically as the X-substituent on the ligand is changed. It was also observed that a correlation exists between the cathodic reduction potentials ( $E_{\text{pc}}$ ) and the  $k_1$ 's within each series. There are several ligand variations whose effects systematically alter the Mo(VI)  $k_1$ 's and  $E_{\text{pc}}$ 's. These individual effects will be considered separately and their cumulative effect will also be described.

STUDIES ON EXTRACTABLE CONSTITUENTS OF POLYPORUS SULFUREUS. Michelle D. Makanas\* and James B. Patrick, John Baker Daffin Department of Chemistry, Mary Baldwin College, Staunton, Va. 24401. A large specimen of the fleshy fungus Polyporus sulfureus was subjected to successive Soxhlet extractions with several different organic solvents. Each extract was subfractionated in turn into strong and weak acidic, basic, and neutral fractions. In this way several significant fractions were obtained which were further separated and purified by flash chromatography and Kugelrohr distillation. None of the materials so obtained has yet been identified, but we report preliminary chemical and spectrometric characterization data and details of the isolations.

CARBON-13 NUCLEAR MAGNETIC RESONANCE SPECTRA OF SOME MESOIONIC XANTHINE ANALOGS. G.O. Mbagwu, R.G. Bass and R.A. Glennon, Depts. of Chem. and Pharm. Chem., Virginia Commonwealth Univ., Richmond, Va. 23284.

Natural abundance  $^{13}\text{C}$  NMR chemical shifts have been experimentally determined for a series of mesoionic thiazolo[3,2-a] pyrimidine-5,7-diones. The spectral data are compared to those of related mesoionic dihydrothiazolo[3,2-a] pyrimidine-5,7-diones and mesoionic 1,3,4-thiadiazolo[3,2-a] pyrimidine-5,7-diones.

Reasonable correlation between the observed  $^{13}\text{C}$  NMR chemical shifts and CNDO/2 total charge densities have been obtained for the different carbon atoms of 8-methyl thiazolo[3,2-a] pyrimidine-5,7-dione.

The support of this research in part by U.S. Public Health Services (Grant No. HL-22566) and the School of Graduate Studies, Virginia Commonwealth University is gratefully acknowledged.

AN INDUSTRIAL SABBATICAL. William H. Myers, Dept. of Chem., Univ. of Richmond, Richmond, Va. 23173. The author spent a fifteen month period from May of 1981 to August of 1982 on sabbatical leave, working in the Research and Development Laboratories of Ethyl Corporation in Baton Rouge, Louisiana. A brief report on the experience will be given, along with suggestions to those who might consider doing something similar. The suggestions will include both observations on the benefits likely to accrue to the academic chemist and to the industrial research group and cautions to consider to make the experience go more smoothly.

AROMATIC AMINE - HALOBORANES: EVIDENCE FOR TRIGONAL BORONIUM CATIONS. W. H. Myers and D. H. Reid\*, Dept. of Chem., Univ. of Richmond, Richmond, Va. 23173. The halogenation reactions of borane adducts of 2-picoline, 2,6-lutidine, 3,5-lutidine, and 2,4,6-collidine were monitored by  $^1\text{H}$  nmr. Signals due to both aliphatic and aromatic protons in the various adducts showed a downfield shift as size and/or number of halogens increased. These downfield shifts can be accounted for by a combination of steric compression and inductive effects. The last step of halogenation is accompanied by an upfield shift of the signals due to protons in the 2 or 6 positions of the pyridine ring, a further downfield shift of signals due to protons in the 3, 4, or 5 positions of the ring, as well as by the appearance of conductivity in the solution. These observations are attributed to the formation in solution of trigonal boronium cations. These compounds have been isolated and characterized.

CALORIMETRIC STUDIES OF ACTIVE-SITE LIGAND INTERACTIONS WITH GLUTAMINE SYNTHETASE FROM *E. COLI*. Sue H. Neece,\* Eileen G. Gorman,\* & Ann Ginsburg,\* NHLBI, NIH, Bethesda, MD 20205. Heats of binding the active-site ligands L-glu, the L-glu analog L-met-S-sulfoximine, and the ATP analog adenylyl-imidodiphosphate (AMP-PNP) to the unadenylylated, manganese form of dodecameric glutamine synthetase (GS) from *E. coli* were measured in a batch-type calorimeter at pH 7.1 and 30°C. Separate determinations in buffers with different heats of protonation indicated that proton effects were negligible for each binding reaction. Values of  $\Delta H$  ( $\pm 1$  kcal/mol) are given per mole of enzyme subunit for saturation with ligand: For L-glu,  $\Delta H = -6.2$ ; for L-met-S-sulfoximine,  $\Delta H = -15.1$ ; for AMP-PNP,  $\Delta H = +1.3$ ; for L-met-S-sulfoximine binding to the Mn-GS-AMP-PNP complex,  $\Delta H = -13.5$  kcal/mol. The binding of L-glutamate is considerably less exothermic than that of the L-glutamate analog, and in contrast to  $\Delta H = -5.7$  kcal/mol for ADP binding to Mn-GS (Shrake *et al.*, Biochemistry 16, 4372, 1977), the binding of AMP-PNP is slightly endothermic.

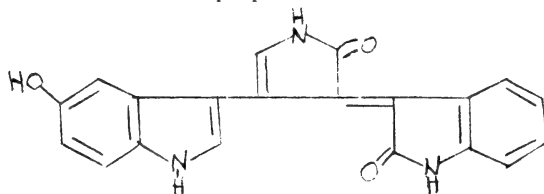
TITRIMETRIC AND ULTRAVIOLET STUDIES ON ALKYL HYPOBROMITE. Nina M. Roscher and Chinh K. Nguyen\* Dept. of Chemistry, The American Univ., Washington, DC 20016

Alkyl hypobromites are prepared by treating tertiary alcohols with bromine using mercuric oxide as the catalyst with pentane as the solvent. The formation of the alkyl hypobromites was confirmed by ultraviolet and titrimetric data in this study.

Spectrophotometric measurements of samples of the reaction mixture were made on a DMS 90 UV-Visible spectrophotometer. Ultraviolet scans were performed from 440 to 240 nm to confirm the disappearance of bromine at 415 nm and the presence of the alkyl hypobromite at 280 nm.

In the titrimetric studies, samples of the reaction mixture were quenched by an acidified potassium iodide solution. The resulting mixture was titrated against a sodium thiosulfate solution and then against a sodium hydroxide solution. The titrimetric results indicated an appreciable yield of the alkyl hypobromite.

FURTHER STUDIES ON THE ISOLATION AND CHARACTERIZATION OF VIOLACEIN. Jo Ann Noble\* and Nina M. Roscher\*, Dept. of Chemistry, The American Univ., Washington, D. C. 20016. Based on the results of synthetic studies by earlier researchers, the following structure has been proposed for violacein:



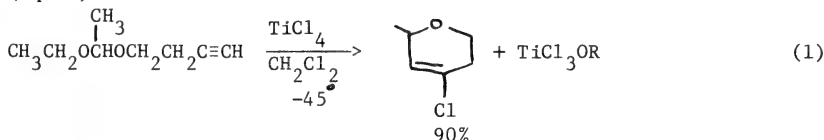
In an attempt to confirm the above structure via modern spectroscopic techniques including UV, IR, NMR and mass spectroscopy, the properties of violacein in various organic solvents was examined. Further characterization of violacein was investigated by performing the standard test for siderophores, Iron-chelating substances. The results from these preliminary studies will be presented.

THE IDENTIFICATION OF PRODUCTS FORMED IN THE EPOXIDATION OF MONO-TERT-BUTYL-p-BENZOQUINONE. Kahnne M. Pham\* and Elizabeth M. Hairfield, John Baker Daffin Laboratory, Department of Chemistry, Mary Baldwin College, Staunton, VA 24401. Many workers have studied the importance of epoxides in metabolism. In addition, epoxy groups are present in numerous antitumor antibiotics and carcinogens. In this research project, the epoxidation reaction of mono-tert-butyl-p-benzoquinone with alkaline hydrogen peroxide is investigated. Extraction methods, flash chromatography, thin-layer chromatography and spectroscopic studies are carried out to classify the products formed from the epoxidation reaction with alkaline hydrogen peroxide. Results obtained show the presence of four products formed, one of which is an epoxide, and the remaining three products are thought to be carboxylic acids. Further work is required to confirm the presence of carboxylic acids. The difficulties encountered in the study are discussed.

MUTUAL INTERACTIONS OF IRON AND URANIUM REDOX STATES IN GLASS MELTS USED FOR NUCLEAR WASTE IMMOBILIZATION. Henry D. Schreiber, Department of Chemistry, Virginia Military Institute, Lexington, VA 24450; Leslie M. Minnix & Barbara E. Carpenter, College of William and Mary; G. Bryan Balazs, Washington and Lee University; and Todd N. Solberg, Virginia Polytechnic Institute.

Uranium establishes the U(VI)-U(V)-U(IV) redox equilibria in borosilicate glass melts, while iron can exist as Fe(III), Fe(II), or Fe(0) in equivalent melts. Borosilicate glasses used in nuclear waste immobilization are required to incorporate uranium into their structures in the presence of the multivalent element iron. A basic understanding of the mutual interactions by electron exchange of the uranium and iron redox states will aid in the scientific basis for nuclear waste immobilization. For one-electron reductions in borosilicate melts at 1150°C at a particular oxygen fugacity, U(VI) is easier to reduce than is Fe(III), which in turn is easier than U(V). Fe(III) does not oxidize uranium, nor does Fe(II) reduce uranium.

A NEW SYNTHESIS OF 4-HALO-5,6-DIHYDRO-2H-PYRANS. D. W. Seamon\*, W. H. Bunnelle, and D. W. Thompson, Dept. of Chem., Col. of William and Mary, Williamsburg, VA 23185. The acetals derived from homopropargyl alcohols and ethyl vinyl ether undergo Lewis acid catalyzed cyclization to give 4-halo-5,6-dihydro-2H-pyrans (eqn 1).



Results with several acetals and Lewis acids will be presented.

UTILIZATION OF THE HEWLETT PACKARD 5970 GC/MS FOR THE ROUTINE CONFIRMATION OF THE 11-NOR-DELTA-9-CARBOXYLIC ACID URINARY METABOLITE OF MARIHUANA. Robert K. Simon and R. Hugh Granger, AMERICAN MED. LABS., INC. Rapid, low cost confirmation of the urinary metabolite of marihuana, 11-nor-delta-9-COOH is achieved with the new HP capillary GC/MS system which features air cooled pumps and simple, convenient attachment to many capillary GC units. Deuterated 11-nor-delta-9-COOH serves as the internal standard for the method. Hydrolyzed urine is extracted with hexane/ethyl acetate and the metabolite is derivatized with both TMAH in DMSO and IODOMETHANE to yield the methyl ether, methyl ester derivative. Comparison of this procedure to standard packed column EI and CI methods show that the 5970 procedure is selective, sensitive and precise. A detection limit of 1 nanogram per milliliter has been documented. Correlation of the described procedure with the Syva Emit DAU marihuana urine screen shows greater than 95% correlation in specimens providing an immunological response greater than 50 ng/ml. The relative low cost of the HP 5970 makes it attractive as a GC/MS alternative for labs conducting drug testing.

AN ELONGATED FORM OF 5.8S rRNA: A GENE VARIATION. Dave Smith and Thomas O. Sitz, Department of Biochemistry and Nutrition, Virginia Tech, Blacksburg, VA 24061. The 5.8S rRNA is found in eucaryotic cells bound to the 28S rRNA in the large ribosomal subunit. When whole cell RNA preparations isolated from rat or mouse tissue were separated on high resolution polyacrylamide gels, two bands of 5.8S rRNA were observed, a major band followed by a less intense minor band. This minor form represented 15 to 40% of the total 5.8S rRNA depending on the source of tissue. Sequence analysis and the kinetics of formation showed that this minor form was elongated at the 5' end and is not a precursor. The sequence of the minor form was found to be p(C)CGAUACG--which is five or six nucleotides longer than the major form and has a heterogenous termini. The DNA sequence for this region in rat has been reported to be -- CCGTACG --. This would suggest that gene heterogeneity leads to an insertion of an A residue in the ribosomal precursor RNA which changes the processing site.

SYNTHESIS OF 2 SUBSTITUTED 4,6-DIHYDROXYPYRIMIDINES. F. T. Smith\*, W. H. Soine and B. van't Riet, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298. Inhibitors of ribonucleotide reductase have been shown to be active against L1210 leukemia. Several compounds containing the catechol function with a planar substituent are known to be effective against this enzyme. In order to investigate the importance of the catechol functionality we have prepared a number of 2 substituted 4,6-dihydroxy pyrimidines. The appropriate acid was converted to the acid chloride and subsequently to the amide. Thionyl chloride was used to dehydrate the amide to the corresponding nitrile. The Pinner synthesis gave the imino ester which upon reaction with ammonia gave the corresponding amidines. The amidines could be easily condensed with diethyl malonate in sodium ethoxide to give the corresponding 2 substituted 4,6-dihydroxy pyrimidines in good yields. The 2 substituent included methyl, phenyl, 3-hydroxy-, 4-hydroxy and 3,4-dihydroxyphenyl. (Supported by the Jeffress Memorial Trust).

THERMAL REDUCTION OF CHLORDECONE IN THE PRESENCE OF ALCOHOL. W. H. Soine, T. R. Forrest\* and J. D. Smith, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298. It was observed that chlordane (CD) underwent reduction to chlordane alcohol (CDOH) if a methanol solution of CD was analyzed using gas chromatography. This study was to determine the conditions necessary for this reaction and steps for minimizing or preventing the reduction. Both primary and secondary alcohols when co-injected with CD were found to cause the reduction while no reduction was observed with *t*-butanol or aprotic solvents. In general, the hotter injection port (240 to 360°C) caused more reduction to occur. When CD was heated with benzyl alcohol the major products formed were CDOH and benzaldehyde. Finally, simultaneous injection of CD, alcohol and magnesium chloride increased reduction of CD relative to a mixture without magnesium. Based on these results it appears that the reduction was thermally catalyzed in the injection port and appears to go via a mechanism comparable to the Meerwein-Ponndorf-Verley reduction.

SYNTHESIS AND BIOLOGICAL EVALUATION OF <sup>103,106</sup>Ru-β-RUTHENOCENYLALANINE. W. H. Soine, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298; C. E. Guyer\* and F. F. Knapp, Jr.\*, Nuclear Medicine Group, Oak Ridge National Laboratory, Oak Ridge, TN. The potential application of the ruthenium radionuclides in diagnostic medicine necessitated the synthesis of radiolabeled ruthenocenes in which the side chain could be modified to provide tissue specificity. This required synthesis of the synthetically versatile quaternary ammonium salt, <sup>103,106</sup>Ru-ruthenocenylmethyltrimethyl ammonium iodide (I). Carrier free <sup>103,106</sup>Ru-ruthenocene was synthesized from <sup>103,106</sup>RuCl<sub>3</sub> using TiCl<sub>3</sub>·H<sub>2</sub> and cyclopentadienylsodium. The ruthenocene ring was functionalized using the Mannich reaction to give <sup>103,106</sup>Ru-dimethylaminomethylruthenocene which was quaternized with methyl iodide to give I in 20% overall yield. From this intermediate we prepared carrier free <sup>103,106</sup>Ru-β-ruthenocenylalanine (II) by homologation of the side chain using sodio diethylformomdomalonate followed by basic hydrolysis to II. II was evaluated as a pancreatic imaging agent in rats but no selective uptake in the pancreas was observed.

DIFFERENTIATION OF SIDE CHAIN POSITIONAL ISOMERS OF AMPHETAMINE. W. H. Soine and M. N. Thomas\*, Dept. of Pharm. Chem., MCV/VCU; R. E. Shark\*, J. Scott and D. T. Agee\*. Drug Examination Section, Bureau of Forensic Science, Consolidated Lab. of Virginia, Richmond, VA. The eleven side chain positional isomers of amphetamine can be distinguished using a combination of color tests, thin-layer chromatography and mass spectrometry. The primary amines, 1-phenylpropylamine and β-methylphenethylamine, exhibited chromatographic behavior similar to amphetamine but were readily differentiated using mass spectrometry. The mass spectra of N-methylphenethylamine was very similar to amphetamine, but using color tests and chromatography it was readily differentiated from amphetamine.

RNA METHYLATION IN FREE AND BOUND POLYSOMES. Susan Spittle and Thomas O. Sitz, Department of Biochemistry and Nutrition, Virginia Tech, Blacksburg, VA 24061. The late cytoplasmic 2'-O-methylation of 5.8S rRNA is low in cancer cells and elevated in fully differentiated adult tissues. There is also a correlation of methylation with the amount of free and bound polysomes, i.e. the amount of bound polysomes is high in liver but low in hepatoma cells. It will be important to understand the functions of these late cytoplasmic modifications of ribosomal RNA and what impact they have on protein synthesis. We have developed a post-labeling procedure that will allow us to measure methylation levels in free and bound polysomes isolated from rat liver. This procedure and the results obtained will be presented.

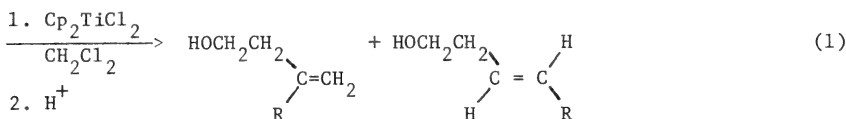
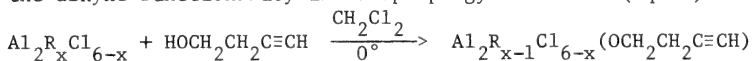
PHOTOLYSIS OF MONOSUBSTITUTED UNBRANCHED LONG CHAIN ALKYL-CYCLOHEXANES. Wayne M. Stalick, George W. Mushrush, and S. Patil\*, Dept. of Chemistry, George Mason University, Fairfax, VA 22030

Ultra-violet irradiation of long chain alkylcyclohexanes with a medium pressure quartz mercury vapor lamp for periods of 8 hrs to 6 days caused free radical decomposition. Analysis of the products was made by capillary gas chromatography. This showed the presence of most of the expected straight chain alkanes and 1-alkenes in addition to their cyclohexyl counterparts that would normally be found from a random free radical decomposition mechanism. It is noted that higher molecular weight products are also produced in substantial amounts. These somewhat unexpected products are most likely produced by recombinations of the decomposition radicals present. (Supported by a George Mason University Research Grant)

SOME PRESSURE-VOLUME-TEMPERATURE MEASUREMENTS ON LIQUID CRYSTALLINE ALKYL- AND ALKOXY-CYANOBIPHENYLS. Vincent J. Sullivan\*, Glen C. Campbell\* and Robert A. Orwoll, Dept. of Chem., Col. of Wm. and Mary, Williamsburg, VA 23185. The melting of a thermotropic liquid-crystalline phase under the usual condition of constant pressure is examined in terms of a 2-step process: a phase transition at constant volume followed by an isothermal expansion. The total entropy change  $\Delta S_p$  is the sum of the entropy change  $\Delta S_v$  resulting from the disordering at the phase transition and the entropy change  $(\partial S/\partial V)_T \Delta V$  associated with the latent volume  $\Delta V$  at the transition. Measurements of  $(\partial P/\partial T)_V = (\partial S/\partial V)_T$  and  $\Delta V$  for alkyl and alkoxy derivatives of cyanobiphenyl lead to the conclusion that  $\Delta S_v$  is the smaller component of  $\Delta S_p$  at the nematic-isotropic transition of these compounds. (Supported by NASA Grant NAG-1-144.)

ISOLATION AND RECONSTITUTION OF LOW DENSITY LIPOPROTEINS (LDL): CONTINUING STUDIES OF DELAYED-TYPE HYPERSENSITIVITY TO FOODS. Rosalie A. Tamburri\* and Margaret F. Pinkston, Department of Biochemistry, Mary Baldwin College, Staunton, VA 24401. It is hypothesized that a defective plasma lipoprotein could serve as the sensitizing agent for delayed-type hypersensitivity (DH) to certain foods containing highly saturated triglycerides. In an attempt to identify the specific causal agent, isolation of low density lipoproteins (LDL) from the blood serum of sensitive (test) and non-sensitive (control) persons was effected by precipitation procedures using heparin and  $Mn^{+2}$  and  $Mg^{+2}$ . The LDL was then partially delipidated with heptane and reconstituted with known cholesteryl esters. Following reconstitution, the LDL of test and control were compared using isoelectric focusing in both agarose and polyacrylamide gels. The banding patterns of test and control showed distinct differences. It cannot yet be concluded that this difference is due to a defective apolipoprotein, because further characterization of reconstituted LDL is necessary, but the evidence suggests that the research may be progressing in the right direction. Attempts will be made to incorporate saturated triglycerides as well as cholesteryl esters in the reconstituted lipoproteins.

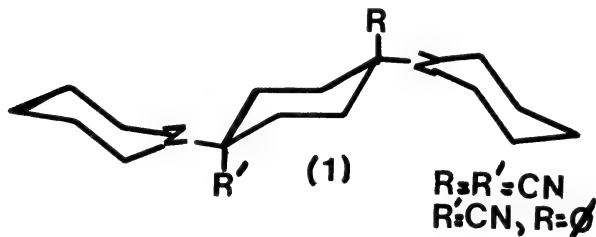
SUBSTITUTED CYCLOPENTADIENYL COMPOUNDS AS CARBOMETALLATION CATALYSTS. David W. Thompson and D. W. Moore\*, Dept. of Chem., Col. of William and Mary, Williamsburg, VA 23185. Bis( $\eta^5$ -cyclopentadienyl)titanium dichloride used with aluminum alkyls catalyzes efficiently the polymerization of alkenes and alkynes via a facile repetitive carbometallation reaction sequence. We have adapted this titanium-aluminum system to give a single, non-repetitive, carbometallation of the alkyne functionality in homopropargyl alcohols (eqn 1). However, the use of



the ring-unsubstituted  $\text{Cp}_2\text{TiCl}_2$ , gives a mixture of regioisomers. We will present studies with the substituted cyclopentadienyl compounds,  $(\text{CpMe})_2\text{TiCl}_2$ ,  $(\text{Cp-}t\text{-Bu})_2\text{TiCl}_2$ , and  $(\text{CpMe}_5)_2\text{TiCl}_2$ , and describe their effect on the distribution of regioisomers.

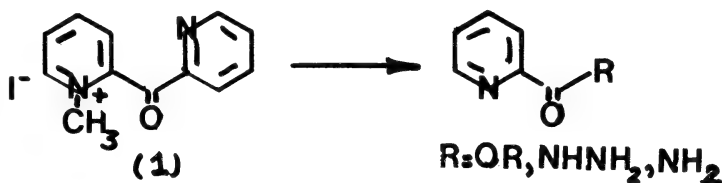
APPLICATIONS OF MICROCALORIMETRY TO LIQUID/SOLID INTERACTIONS. J. P. Wightman, Chem. Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. There are a number of experimental approaches to the study of interactions at the liquid/solid interface including thermodynamic, kinetic and spectroscopic which represent attempts to understand how molecules from the liquid state interact with solid surfaces. A powerful thermodynamic tool is calorimetry where heats of immersion (or wetting) are measured directly as the liquid wets the solid surface. In our laboratory, heats of immersion are measured in a Calvet microcalorimeter. The operation of this calorimeter will be described briefly. Emphasis will be placed on the discussion of the heats of immersion determined in a number of systems including: (1) interaction of  $\text{HCl(aq)}$  and water with inorganic oxides; (2) interaction of organic liquids with coals; and, (3) interaction of primer solutions and water with Ti and Ti alloy. (Research supported by MMRR at Virginia Tech and the Commonwealth of Virginia.)

PHENCYCLIDINE(PCP)ANALOGS: SYNTHESIS AND EVALUATION. R. L. Williams and James Hunt, Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901, and Dept. of Chem., Old Dominion Univ., Norfolk, VA 23508. As part of a continued search for a possible PCP antagonist, several novel phencyclidine analogs have been prepared and evaluated for possible agonist/antagonist activity in mice. This paper will discuss the synthesis and biological evaluation of these 4-phenyl-1,4-di(1-piperdiny1) analogs. (1).

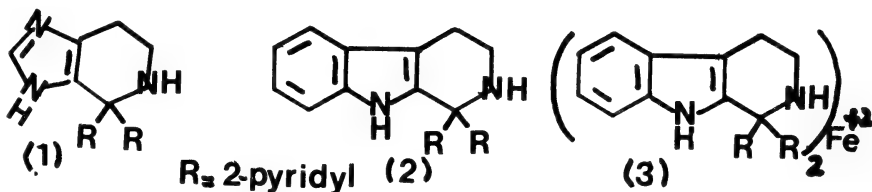




DI-2-PYRIDYLKETONE METHIODIDE: A NOVEL PYRIDYLATING AGENT. R. L. Williams and Sandra Neergaard, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23508. Di-2-pyridylketone methiodide (**1**) has been found to be an effective pyridylating agent with certain nucleophiles. The methiodide (**1**) can be selectively converted to the corresponding pyridyl esters, hydrazide and amide with the appropriate reagents. The reaction of (**1**) with other nucleophilic species such as  $\text{NaBH}_4$ , phenylmagnesium bromide and cyanide ion will be discussed.

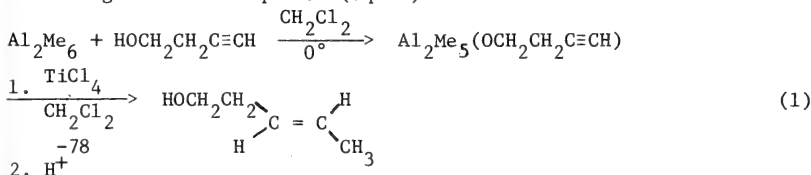


NEW HETEROCYCLIC NEUROMUSCULAR BLOCKING AGENTS. R. L. Williams and Sandra Neergaard, Department of Chem. Sci., Old Dominion Univ., Norfolk, VA 23608. Recently several diaryl-4,5,6,7-tetrahydro-imidazo-[4,5,-C] pyridines (**1**) have been shown to exhibit neuromuscular blocking activity in mice. This work has now been extended to include the tryptamine ligand and the corresponding iron complex (**2**) and (**3**). These new compounds appear to be depolarizing agents in contrast to the histamine analogs which have nondepolarizing neuromuscular blocking activity. This paper will discuss the synthesis and evaluation of these novel compounds.

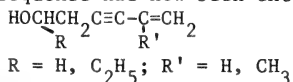


AN APPLE A DAY. John H. Wise, Dept. of Chemistry, Washington and Lee Univ., Lexington, VA 24450. AN APPLE microcomputer has been in use for nearly one year in the department. A variety of programs for demonstrations, calculations of laboratory reports, and tutorials have been developed and will be described. On-line data acquisition and treatment is planned for the future.

SELECTIVE METHYLATION OF ENE-YNE-OLS VIA TITANIUM TETRACHLORIDE-TRIMERHYL-ALUMINUM. T. J. Zitzelberger\* and D. W. Thompson, Dept. of Chem., Col. of William and Mary, Williamsburg, VA 23185. We have shown that  $\gamma$ -alkynols are selectively carbometallated with a  $\text{TiCl}_4\text{-AlMe}_3$  reagent system according to the following reaction sequence (eqn 1).



The methylation occurs with a wide variety of alkynols at the carbon furthest from the hydroxyl group; the carbometallation occurs in a syn fashion. This reaction sequence has now been extended to ene-yne-ols of the type



## Education Section

INDIVIDUALIZED CONTRACTUAL EVALUATION FOR BIOLOGY STUDENTS. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. Grade distribution of 349 general biology students (during a six-year period) using traditional evaluation methods was compared with that of 281 general biology students (during a separate six-year period) using a student-instructor contractual agreement. For the contract agreement, each student was allowed to select both the activities and percent weight of each activity used in deciding their grade. Success rate of students (i.e., those attaining at least "C") using the contract approach increased by nine percent (from 70% to 79%) over those using traditional evaluation for the six-year period. During the final three years of using the contracts, rate of success in biology averaged 85%. Among those surveyed, students liked the opportunity to (1) de-emphasize exams as sole factor in determining their grade and (2) selecting those activities on which their grade is based.

CONTRASTING AB AND DF BIOLOGY STUDENTS. H.S. Adams, A.M. Dutrow\*, and K.S. Bowers\*, D.S. Lancaster Cmnty. Col., Clifton Forge, VA 24422. Twenty-one variables were compared for AB and DF general biology students. The only variables for which the groups did not differ significantly ( $\alpha = .01$ ) were age and length of time elapsed from high school graduation before taking the course. For all other variables, including high school grades, rank in graduating high school class, and CGP (Comparative Guidance and Placement) scores, the AB group was significantly higher. Discriminant analysis revealed misclassification of five DF and eight AB students. Means for misclassified DF students were considerably lower in high school rank and CGP motivation, math interest, and biology interest scores than those for the AB group with which they should have been classified. The AB students who were predicted to have received D or F differed from the DF group by averaging higher on CGP reading, sentence, and math scores.

NATIONALLY DEVELOPED ENVIRONMENTAL EDUCATION PROGRAMS RECENTLY AVAILABLE IN VIRGINIA. TERESA M. AULDRIDGE\*, VA DEPT. OF EDUCATION, BOX 6Q, RICHMOND, VA 23216 AND BRENDA A. BAKER\*, HENRICO CO. SCHOOLS, P. O. BOX 40, HIGHLAND SPRINGS, VA 23075. Project Learning Tree and Project WILD were both initiated by the Western Regional Environmental Education Council. They are interdisciplinary environmental education programs intended to supplement the regular curriculum grades K-12. The seven major principles of PLT focus on the forest environment and our use of its resources, while WILD emphasizes the ecology and management of wildlife. A 1981 grant from the American Forest Institute made PLT available free to any educator in Virginia who attends a workshop. To date, over 1,700 teachers have received the materials. Project WILD is being funded jointly by the VA Commission of Game & Inland Fisheries and the Izaak Walton League. Virginia was one of three states in the nation to participate in field testing the rough draft of WILD during the 1982-83 school year. Final versions will be available for educators who attend workshops beginning in October 1983.

CRYSTAL WORLD - ITS USE AS A CLASSROOM. R. Wesley Batten, Director, Science Presentations Division, Science Museum of Virginia, Richmond, Virginia (23220). The world class exhibition at the Science Museum of Virginia on the science of crystallography is a rich instructional resource for illustrating difficult concepts in science. Crystal World may be used as an activity base and as a project model for elementary and secondary science. Crystal chemistry, states of matter, properties of metals, atomic structure, symmetry, physics of light, refraction, and mineral identification are but a few of the topics that stimulate students' understanding of basic scientific truths.

CREATIONISM THROUGH THE BACKDOOR: THE CASE OF LIBERTY BAPTIST COL. Michael L. Bentley, Dept. of C. & I., Sch. of Ed., Univ. of Va., Charlottesville, VA 22903. On Dec. 10, 1982 the Va. Board of Ed. provisionally approved the biology program for the preparation of public school teachers at Liberty Baptist College, Lynchburg, Va., despite the protest of the ACLU, Va. Academy of Science and others that the college's program taught creationism as science. Va. certification also extends automatically to 34 other states.

The LBC program was subjected to the standard review procedure for programs seeking approval for teacher education. The criteria for approval were formulated before creationism became a significant issue in science education. Only one scientist was involved in the procedure. The criteria for approval and the input of the scientific community in such cases need a second look. Even educated laymen do not apparently appreciate the scientific issue involved in teaching creationism as science. The situation is evidence of the need for more emphasis in education on the philosophy of science.

THE ROLE OF THE FAMILY IN THE PROMOTION OF SCIENCE LITERACY. Elizabeth A. Cornell\*, VA Inst. of Marine Science, Sch. of Marine Science, Col. of William and Mary, Gloucester Point, VA 23062. Final results from a NSF-funded series of studies being conducted by the Smithsonian's Chesapeake Bay Center for Environmental Studies and the VA Inst. of Marine Science will be presented. The series includes characterizing the families visiting science centers, measuring participation rates and persistence of family members whose youngsters bring home "take-home, family activities" from school, characterizing what makes a good family-learning situation, and how parents and children teach and learn from each other. Theories and models of adult education and the role of the family in informal learning are discussed. Concepts are drawn together from a wide variety of disciplines (e.g., psychology, sociology, museum education, higher education).

FORMATION OF ECOLOGICAL CONCEPTS BY UPPER ELEMENTARY STUDENTS. Julia H. Cothron, Hanover County Sch., Ashland, Va. 23005, & Ertle Thompson, Sch. of Ed., Univ. of Va., Charlottesville, Va. 22903. SCIS students, grades 4-6, completed a multiple-choice and free-sort task. Grade and ability, not sex, influenced concept attainment and similarity of conceptual system to discipline structure. Sequence was not influenced by grade, ability, sex. Concept attainment was promoted by conceptual system similar to discipline structure. Sixth graders recognized life requirements, interactions via food, mineral, gas exchange, and community groups, but not attributes of higher-order concepts: producer, consumer, decomposer, environmental factors. Discipline experts, not students, related examples to higher-order concepts. Recommendations for K-6 curriculum were: (1) promote conceptual system similar to discipline structure, (2) base concept maps upon lower-order concepts or attributes, (3) eliminate higher-order concepts, (4) emphasize interactions of plants, animals, decayers, and materials, feeding relationships, and life requirements.

CHEMICAL WASTE IN SCHOOLS. Timothy W. Cotman\*, Va. Dept. of Education, Box 6Q, Richmond, VA 23216. This seminar will document the efforts of the Science Service of the Virginia Department of Education, in conjunction with several other agencies, to purge unwanted and excessively dangerous chemicals from public schools in Virginia. The need for this action will be examined in view of the importance of the laboratory aspect of secondary chemistry courses, regulatory considerations, practical implementation and the actual mechanics of the present project.

POTENTIAL OF THE VIDEODISC IN INTERACTIVE INSTRUCTION. Mark Delp,\* Division of Instructional Media and Technology, Virginia Department of Education, Richmond, Virginia 23216. The impact of employing interactive high technologies to truly individualize instruction is just beginning to be acknowledged. Up to this time, the interactive technologies most employed in instruction (computers and most currently microcomputers) have been limited to the presentation of alphanumerics, graphics and sound, primarily because of mass storage limitations. The optical laser read videodisc makes the integration of full color motion and stereo sound with microprocessor display generation and control a reality. Three levels of interactivity are possible and will be demonstrated in this session using a laser reflective optical videodisc player with built-in microprocessor.

A SYSTEMS APPROACH TO DEVELOPING EFFECTIVE PROGRAMS OF SCIENCE. Joseph Exline, Associate Director of Science, VA Department of Education, P. O. Box 60, Richmond, VA 23216. Accepting the fact that criteria have long been available for identifying exemplary programs of science and that valid research has long been available for pinpointing the shortcomings in science programs, it is contended that the major problem in providing a quality science program has to do with the lack of effective program implementation on a large scale and with a long range commitment. The crucial first step to improving efforts in science education is the development of a sound long range plan. Developing a systems approach implementation plan is the crucial second step to improving effectiveness in science education and is the step which has been most neglected. The systems approach plan must consider at least the following: teacher background, administrative support, learning environment, instructional materials, facilities and equipment, and community support.

AGRICULTURE IN THE CLASSROOM. Joyce H. Jones, Dept. of Poul. Sci., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. Recent studies by the American Farm Bureau have determined that public school teachers in both urban and rural settings rely on classroom textbooks for teaching information relating to agriculture. Frequently, classroom textbooks and library resource materials present agricultural information that is outdated and/or inaccurate.

During the last twenty years, Agricultural research has produced numerous improvements in plant and animal agriculture. These include improvements through genetics, physiology, nutrition, management, and/or animal behavior research. Agricultural research and resulting improvements in production, quality and cost factors of agricultural commodities can become educational classroom resource tools to introduce students to a) the scientific method and b) how research results can affect daily lives. Science and Technology in the Poultry Industry has been presented in teacher workshops by Cooperative Extension Service Specialists and Agents. Follow-up teacher evaluations cite the availability of accurate agricultural information and resulting classroom discussions and activities (i.e., simple experiments) as generating positive student understanding of the necessity for research and an appreciation of the problems faced by agricultural commodity farmers.

THE CHANGING NATURE OF MARINE SCIENCE EDUCATION. Harris B. Stewart, Jr., Ctr. for Marine Studies, Old Dominion Univ., Norfolk, Va. 23508 Susanne S. Jackman, Applied Marine Res. Lab., Old Dominion Univ., Norfolk, Va. 23508. The teaching of marine science at our schools and colleges is changing as man's perception of his relationship to the marine environment changes. The eco-hysteria of the 1960's and 1970's resulted in environmental approaches and policies that are now being reevaluated in the light of new knowledge and of further consideration of their socio-economic implications. Educators at all levels must develop their own means of keeping abreast of the advances in our scientific knowledge of the sea and more particularly in the changing public attitudes towards the sea, its resources, its legal regime, and its interactions with the land. Courses called "marine science" or "oceanography" will need to be expanded to include such marine aspects as the legal and the economic ones. Coastal zone management, resource recovery, marine technology, and international aspects might well be covered in addition to the traditional fields of marine biology, chemical, geological and physical oceanography.

WHO OWNS THE BIOLOGY CURRICULUM? Wayne A. Moyer, National Association of Biology Teachers, 11250 Roger Bacon Drive, Reston, VA 22090. The textbook is the curriculum for most teachers; but who owns the textbooks? The Federal Government is out of the curriculum writing business, perhaps for good. Commercial publishers are under pressure to modify their texts to meet various demands. Local school authorities tend to concentrate curriculum responsibility in the hands of administrators, treating teachers like hired hands. Who then is responsible for what is taught in biology classes? This presentation will review trends in biology texts as seen in examples printed during the last 60 years, while examining the question, "What is basic in biology?" Human ecology seems to be emerging as the answer for the 80s. The role of classroom teachers in curriculum development will be considered, and includes: (1) cultivating curiosity about the natural world, (2) accurately transmitting our scientific heritage, (3) departing from the textbook to encompass other authorities, and (4) reclaiming the teacher's academic birthright to write curricula.

#### SEA GRANT IN VIRGINIA: WHAT IT'S ALL ABOUT.

William L. Rickards, Virginia Graduate Marine Science Consortium, University of Virginia, Charlottesville, VA 22903

The Virginia Sea Grant Program is an inter-institution, inter-disciplinary program of applied research, education and advisory activity designed to foster the wise development and management of marine and coastal resources. Research projects cover such diverse subjects as improved techniques for farming oysters and clams, the biology of commercially exploited organisms, improved weather forecasting for Chesapeake Bay, uses for seafood processing wastes, and anti-cancer substances from marine animals.

The Education portion of the Program emphasizes educating teachers through workshops, information dissemination systems, and field activities as well as the development of marine 4-H educational materials.

Through the Marine Advisory Services (MAS), technical information is transferred to the private sector and state agencies on subjects including commercial and recreational fishing, marine trades and businesses, seafood processing and marketing, and aquaculture.

THE GOVERNOR'S SCHOOL INTEREST CENTER

Betsy M. Waring, Mathematics and Science Center, 2401 Hartman Street, Richmond, VA 23223

The Governor's School Interest Center is a non-residential program, funded by the Department of Education, for identified gifted students in 10 counties, four cities and accredited private schools in the Richmond area. The Mathematics and Science Center developed the pilot program for the State in summer 1982. In summer 1983, the Mathematics and Science Center will be one of three centers, and it will offer the only Interest Center program in science and mathematics for gifted students in grades 8-12.

In a Monday through Friday format, students explore a topic through lectures, discussions, laboratory investigations, field work, and with visiting consultants.

In summer 1983, interdisciplinary programs in fresh water environments (grades 8-9) and marine environments with emphasis on Chesapeake Bay (grades 10-11) will include camping and on-water experiences. An interdisciplinary chemistry of living systems course will include visits to medical and industrial research centers. All courses will require project work.

## Engineering Section

TECHNICAL SYMPOSIUM. R.D. Kirchner, Presiding. The Engineering Section of the Virginia Academy of Science devoted this year's meeting to discussions of the current crisis in America's science education programs, its effect on the national defense and economic prosperity, and what can and must be done to remedy the situation. Prominent speakers from government, industry, and educational institutions presented their views on various aspects of this vital issue and outlined actions that must be taken to insure the numbers of qualified engineers, scientists, and technical workers needed to compete in the growing worldwide technical revolution. Speakers included Dr. Bernard Kulp, Air Force Systems Command; Bryce Jewett, Jewett Machine Manufacturing Co.; Margaret Marston, National Commission on Excellence in Education; Dr. Marvin Cetron, Forecasting International Ltd.; Dr. John Casteen, State Secretary of Education; Bill Aldridge, National Science Teachers Association; Dr. J. Wade Gilley, The Institute for Science and Technology; Dr. Rodney Hannaman, Reynolds Metal Co.; Nancy Flinn, American Chemical Society; and Pamela Kurstedt, Virginia Polytechnic Institute and State University.

## Environmental Science Section

ZOOPLANKTON POPULATION DYNAMICS OF LAKE ANNA, VIRGINIA, 1973-1982.

John B. Bailey, Environmental Services Department, Virginia Electric and Power Company, Richmond, Virginia 23261. In 1972, Virginia Electric and Power Company impounded the North Anna River to create a 3887 hectare reservoir to provide condensor cooling water for its North Anna Nuclear Power Station. Zooplankton sampling occurred both before (1973-1975) and after (1978-1982) power generation was initiated in 1978. Comparisons of zooplankton density and diversity showed no significant differences between pre and post-operational populations in the reservoir.

TRANSPLANT EXPERIMENTS WITH SUBMERSED AQUATIC VEGETATION IN THE POTOMAC RIVER. Nancy Bartow\* and Virginia Carter\*, U.S. Geological Survey, Reston, Va., 22092. The tidal Potomac River has been nearly devoid of submersed aquatic vegetation since the 1930's. Transplant experiments were conducted at four sites during 1980-1982 to determine whether Vallisneria americana will survive in the tidal Potomac River under present conditions. Exclosures were placed around several transplant beds to test the effect of grazing. At three out of four sites, transplant beds protected by exclosures during the first growing season were successful and regrew the following year. Unprotected plants disappeared or were clipped off by unidentified browsers. Site characteristics play a role in transplant success. Of the characteristics measured (fetch, exposure, substrate, light penetration, sediment nutrients, and heavy metals), substrate and light penetration seem to be most important. Sedimentation from storm events may have been a factor in the elimination of submersed aquatic vegetation. A laboratory study was conducted to investigate the effects of sediment deposition on the emergence of Vallisneria from tubers. About 65 percent of the Vallisneria emerged and grew green leaves when buried in 15 cm of sediment, about 25 percent emerged and grew green leaves when buried in 20 cm, and none emerged when buried in 25 to 55 cm of sediment.

WATER ELEVATION AND SALINITY SURVEY OF LONDON BRIDGE AND WEST NECK CREEKS. Carvel Blair, Stephen Danna\*, and Joung Kim\*, Department of Oceanography, Old Dominion University, Norfolk, VA 23508. Over a one-year interval (February 1982-January 1983) we surveyed water elevation and salinity in the London Bridge-West Neck Creek system. Stations were spaced along the 20-mile stretch from Lynnhaven Inlet (on Chesapeake Bay) to the North Landing River (on the Intra-Coastal Waterway). The upper limit of salinity intrusion varied between 6 and 13 miles upstream from the inlet. Previous studies had found an inverse correlation between salinity and 30-day rainfall. We found the correlation to be much stronger with rainfall during the previous 2 or 3 days than with the previous month. We also found a tidal change in water elevation extending an average of about 10 miles upstream, somewhat farther than the mean salinity intrusion. Celerity of the tidal wave was about 5 cm/sec.

A SURVEY OF ACTION AND ATTITUDES TOWARD URANIUM MINING AND MILLING IN VIRGINIA. Margaret A. Brenner & Joseph Norris, Dept. of Biol., Lynchburg Coll., Lynchburg, Va. 24501. The Marline Uranium Corp. announced on July 21, 1982 that a large deposit of uranium oxide ( $U_3O_8$ ) had been discovered in the Triassic Basin region of south central Virginia. Marline's work in the area of Pittsylvania County has included surface studies and exploratory drilling procedures. Detailed observations of the geology of the area and a proposed plan for the mine/mill complex have also been compiled.

This presentation will explore both the optimistic and pessimistic views of uranium mining and milling by exploring governmental and public response to Marline's plan, and also provide a detailed description of Marline's work thus far and their plans for the future.

ACID RAIN MONITORING IN VIRGINIA. Arthur L. Buikema, Jr. and Boris I. Chevone, University Center for Environmental Studies and Department of Biology and Air Pollution Laboratory and Department of Plant Pathology and Physiology, Va. Polytechnic Institute and State University, Blacksburg, Va. 24061. The Virginia Acid Precipitation Network (VAPN) was established in late 1980 as part of the research activities carried out under the direction of the Technical Advisory Committee to the State Air Pollution Control Board. The purpose of this research is to provide a data base for determining the extent, significance and possible source contributions of acid deposition in Virginia. Since 1982 there are 8 stations in the network. Rain samples are monitored weekly for pH and conductivity. If sufficient sample exists, the concentrations of sulfate, nitrate, chloride, ammonium, calcium, magnesium, sodium and potassium ions are also measured weekly. Two sites are monitored weekly for arsenic, selenium, manganese, vanadium and aluminium. Quarterly all sites are monitored for 19 trace elements.

THE EFFECTS OF DREDGE SPOILS FROM THE ELIZABETH RIVER ON THE CALANOID COPEPOD ACARTIA CLAUSI Renée S. Crupch Dept. of Biol. Sci. Old Dominion Univ. Norfolk VA 23508. A 96-hour, static, suspended particulate bioassay was conducted to assess the effects of dredge spoils from a highly industrialized region of the Southern Branch of the Elizabeth River, VA, on the copepod Acartia clausi. The mortality in all test containers was highly significantly different from controls ( $p < .01$ ) beginning at the 48-hr time interval. The 48-hr and 96-hr LC50's were 13.18% and 12.59% suspended solid elutriate, respectively. The incipient LC50, that which produces 50% mortality over an infinite time, was 17.51% elutriate. The suspended solid elutriate from this region contained high levels of ammonia, high concentrations of heavy metals, and a high silt-clay content. The observed lethal effects may be due to some toxin or combination of toxins, whether ammonia, heavy metals or unmeasured contaminant, as well as physical stress from suspended particulates, found in this heavily industrialized region of the Elizabeth River. Additional research is needed to thoroughly assess the impact of dredge spoils on the zooplankton community.

THE EFFECT OF SEA NETTLE ABUNDANCE ON OTHER TROPHIC LEVELS IN THE LOWER CHESAPEAKE BAY REGION. Michael G. Kelly\* & Dr. David L. Feigenbaum, Dept. of Oceanography, Old Dominion Univ., Norfolk, VA 23508. The abundance of the medusoid stage of the sea nettle, Chrysaora quinquecirrha and other gelatinous and crustacean zooplankton and phytoplankton were investigated at four stations in the Lafayette and Elizabeth Rivers, Virginia, from May to October 1982. The sea nettle, when abundant, directly or indirectly controls much of the life in the water column through its feeding activities. Medusae appeared in early June and the ctenophore, Mnemiopsis leidyi, sharply declined. The crustacean population significantly decreased in the presence of M. leidyi but subsequently increased when the sea nettle reduced the ctenophore population. The crustacean abundance was variable through the second half of the study. Food was not a limiting factor for the crustaceans.

A MATHEMATICAL MODEL STUDY OF WATER QUALITY OF A SMALL TIDAL CREEK. Albert Y. Kuo and Stephen Williams\*, Va. Inst. of Marine Sci., Col. of William and Mary, Gloucester Point, Va. 23062. A one-dimensional mathematical model has been developed for use in small tidal streams to investigate the short-term intra-tidal and diurnal fluctuations as well as the long-term seasonal variations of water quality. The model solves the continuity and momentum equations simultaneously through the use of a semi-implicit finite difference scheme. The solutions of these equations provide water velocity and surface elevation, which are then used to solve the mass-balance equation. The solution of the mass-balance equation describes the longitudinal and temporal distributions of eight dissolved or suspended substances comprising the 'ecosystem'. The model has been calibrated and validated using data from the Little Hunting Creek, a small tidal stream joining the Potomac River. The model has also been used to investigate the cause-effect relationship controlling water quality conditions in the Creek.



SEASONAL COMPOSITION OF PHYTOPLANKTON IN THE ELIZABETH RIVER AND HAMPTON ROADS AREA OF VIRGINIA. Richard Lacouture\*, and H. G. Marshall. Depts. of Biological Sciences and Oceanography, Old Dominion University, Norfolk, Va., 23508.

Monthly collections in Hampton Roads and the Elizabeth River were collected for phytoplankton analysis over a 13-month period. Maximum concentrations occurred in spring and summer, decreasing into fall with lowest numbers in winter. Phytoplankton biomass levels were greatest in early spring and early summer, with fall having the lowest amount. Concentrations were generally greater or comparable in the Elizabeth River when compared to other stations sampled in the lower Chesapeake Bay. With the exception of early spring, the phytoplankton biomass was generally less than what was found in the lower Bay. The phytoplankton also contained an abundant ultraplankton component composed mainly of cyanophycean and chlorophycean species. The dominant species throughout the year included Skeletonema costatum, Leptocylindrus minimus, L. danicus, Asterionella glacialis, Prorocentrum minimum, Cryptomonas spp., and Emiliania huxleyi. The spring populations were dominated by S. costatum with a shift to a combination of ultraplankton and phytoflagellates more prominent in the summer maximum.

SEASONAL COMPOSITION OF PHYTOPLANKTON IN THE LOWER CHESAPEAKE BAY REGION. Richard Lacouture\*, and H. G. Marshall. Depts. of Biological Sciences and Oceanography, Old Dominion University, Norfolk, Va., 23508.

Monthly observations were made at seven stations in the lower Chesapeake Bay for a 13-month period. One hundred ninety-six species were identified with diatoms, dinoflagellates, and an unidentified ultraplankton component the most prominent species. Spring was dominated by small, chain forming diatoms (Skeletonema costatum, Rhizosolenia fragilissima, Thalassiosira nordenskiöldii) and an ultraplankton assemblage <3 µm. Prorocentrum minimum and other dinoflagellates became more abundant in summer along with several Chaetoceros spp. During fall, there was a general increase of the smaller diatoms (S. costatum, Leptocylindrus minimus, Thalassionema nitzschioides) and cryptomonads. A flora similar to the fall assemblage continued into winter, but in lower concentrations. Ubiquitous throughout the year were ultraplankton cells, <3 µm in size, that were mainly composed of cyanophycean and chlorophycean species. Maximum cell concentrations occurred during early spring and mid-summer. Highest phytoplankton biomass levels were in spring and early fall, with the lowest biomass recorded in mid-summer and during winter.

SEASONAL CELL VOLUME AND CONCENTRATION PATTERNS FOR MAJOR PHYTOPLANKTON GROUPS OVER THE NE CONTINENTAL SHELF. H. G. Marshall, L. Jugan\*, C. K. Rutledge\*, P. Zimba\*, and D. A. Randolph\*. Department of Biological Sciences, Old Dominion University, Norfolk, Va. 23508.

Analysis of a data set consisting of 714 station samples from 26 cruises between 1978 and 1982 indicated large scale distribution patterns for the phytoplankton. Areas of high biomass concentrations had closer direct relationships to cell concentrations near the major bay systems and Georges Bank, and over the shelf during seasonal periods of peak development. The seasonal appearance of large sized diatoms and dinoflagellates enhanced the biomass levels during winter and summer. A seasonal progression of increased development from early spring through summer was indicated from the Gulf of Maine southwest coast seaward to Georges Bank. Ubiquitous species over the shelf included Asterionella glacialis, Guinardia flaccida, Leptocylindrus danicus, Rhizosolenia alata, Skeletonema costatum, Thalassionema nitzschioides, Ceratium fusus, Ceratium lineatum, and Ceratium tripos. Supported in part by the NOAA/NEMP Ocean Pulse program.

EFFECT OF SHELF ENVIRONMENT ON YEAR CLASS STRENGTH OF ATLANTIC CROAKER (Microponias undulatus). Brenda L. Norcross, Herbert M. Austin, VA Inst. Mar. Sci., Sch. Mar. Sci., Col. Wm. & Mary, Gloucester Pt., VA 23062, and Sharon K. LeDuc\*, NOAA/NESDIS/ASISC, Columbia, MO 65201. The geographic center of croaker spawning varies in relation to shelf bottom temperatures. These interannual fluctuations in bottom temperatures appear to be linked to timing of seasonal cessation of the southerly wind component resulting in variation in onset and northward placement of croaker spawning. Normal and anomalous wind regimes drive transport mechanisms which affect larval croaker, and therefore significantly impact recruitment of juveniles to the Chesapeake Bay. The effect of wind-driven transport is positive or negative depending on larval position in the water column. Year class strength of Atlantic croaker is strongly dependent upon the coherence between the seasonal wind shift, timing and area of spawn, wind driven transport, and position of larvae in the water column.

USE OF NET BARRIERS TO EXCLUDE STINGING JELLYFISH FROM SWIMMING BEACHES. A. J. Provenzano, D. L. Feigenbaum, C. Blair, D. F. Johnson\*, and M. Kelly\*, Dept. of Oceanography, Old Dominion University, Norfolk, VA 23508. Jellyfish, including the stinging nettle, Chrysaora quinquecirrha, are abundant in summer in Chesapeake Bay. Their presence greatly curtails recreational use of the beaches. Tourism, local business and real estate values are all adversely affected. Experimental jellyfish exclusion zones were established at two public beaches in Norfolk in mid-summer, 1982. An attempt was made to determine technical feasibility of such barriers, the advantages of various netting materials, public acceptance of protected areas and the projected costs of larger scale enclosures. At one site, structural damage to rigid net frames prevented gathering of adequate data on design. At the second site, flexible netting hung from temporary pilings reduced jellyfish abundance within the enclosed area. Public utilization of protected beach was many times higher than adjacent unprotected beach. Seining and flushing of jellyfish out of the enclosure on tidal currents reduced impact of jellyfish which penetrated the barrier. Design modifications, economic studies and season-long feasibility testing of a larger unit are planned for 1983.

ALTERATION OF THE TREE GROWTH TO CLIMATE RELATIONSHIP IN RED SPRUCE (PICEA RUBENS SARG.). L. J. Puckett, U.S. Geological Survey, Reston, Va. 22092. Incremental growth cores were collected from red spruce (Picea rubens Sarg.) trees growing on bedrock and on glacial till at the Hubbard Brook Experimental Forest. Results of regression analyses of tree-growth indices against orthogonally transformed temperature and precipitation data for two periods, 1932-56 and 1956-80, indicate that the relationship of tree growth to climate has been altered. For tree growing over bedrock the responses to climate and to prior growth have decreased. For trees growing over till the response to climate decreased and the response to prior growth increased. Statistical t-tests and F-tests of the climate data of the two periods indicate that climate has been essentially the same. Droughts have occurred in 60 percent of the last 50 years with a peak magnitude in the mid-1960's. It is suggested that toxic  $Al^{3+}$  generated through dissolution of reactive alumina via hydrogen ion neutralization reactions in glacial till soils may be damaging the root systems of red spruce. However as a result of organo-metallic complexes formed in the humus, roots there may not be affected, effectively restricting root systems of trees growing on till to the humus layer. The root systems of trees growing in humus over bedrock would not be so negatively affected.

THE INFLUENCE OF FOREST CANOPIES ON PRECIPITATION CHEMISTRY IN NORTHERN VIRGINIA. L. J. Puckett, U.S. Geological Survey, Reston, Va. 22092. Throughfall was collected in adjacent coniferous and deciduous stands at the Mill Run Research Watershed in northwestern Virginia. Nine sample sets covering a period of 13 weeks between July and November had mean pH values of 4.13, 4.23, and 3.92 for precipitation, deciduous throughfall, and coniferous throughfall, respectively. Beneath both canopy types there was a net gain of  $H^+$ ,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $NO_3^-$ , and  $SO_4^{2-}$  ions and a net loss of  $NH_4^+$  ions. In precipitation  $H^+$  and  $NH_4^+$  provided 71 per cent of the cation charge. Beneath conifers  $H^+$  and  $Ca^{2+}$  provided 68 per cent and beneath hardwood  $H^+$ ,  $Ca^{2+}$ , and  $K^+$  provided 83 per cent of the cation charge.  $SO_4^{2-}$ ,  $NO_3^-$ , and  $Cl^-$  provided 53, 21, and 25 per cent, respectively, of the anion charge in precipitation. Of the anions in throughfall  $SO_4^{2-}$ ,  $NO_3^-$ , and  $Cl^-$  provided 57, 30, and 12 per cent, respectively, beneath conifers and 64, 21, and 14 per cent, respectively, beneath hardwoods. The net gain of  $H^+$  was 95 per cent beneath conifers and 8 per cent beneath hardwoods.  $SO_4^{2-}$  and  $NO_3^-$  ions increased 136 and 209 per cent, respectively, in conifer throughfall and 86 and 51 per cent, respectively, in deciduous throughfall. These results indicate the importance of dry deposition to tree canopies in evaluating potential impacts to forest ecosystems.

OCEAN TIDE RESEARCH AND THE BRAKING OF THE EARTH ROTATION. Ernst W. Schwiderski, Naval Surface Weapons Ctr., Dahlgren, Va. 22448. The paper highlights the centuries' old and colorful history of ocean tide research, which culminated in an ocean tide model that allows a prediction of the water height with an accuracy of better than 10 cm anytime and anywhere in the real world oceans. The constructed tidal waves rotate around fixed points over huge areas in about 12 hours. Among the broad range of vital applications, the mechanism of tidal friction and braking of the earth rotation is explained in some detail. It is shown that while the moon pulls the earth and ocean tides around, the oceans gear into the moving ocean and brake the rotation of the earth, burning about 53% of the tidal energy (ca. 3.56TW for  $M_2$ ) into wasted heat. A more specific paper on "Hydrodynamical Mapping of Global Ocean Tides" will be presented in the session of Astr., Math., and Physics.

AMOUNTS OF PARTICULATES PRESENT IN THE ATMOSPHERE OF LYNCHBURG, VA. Randee Stenroos\*, Lynchburg, Col., Lynchburg, Va. 24503. To find the level of particles present in the atmosphere of Lynchburg Va. pieces of tape were placed in various areas around the city. The tape was left out for 10 hours. It was then collected, placed on microscope slides, and the particles present were counted. Pictures of the particles were made with a Lutz-Ortholux microscope which enabled the author to see the variety of particles present. These results showed: the heaviest concentration in the backyard of a house inside the city. There were roughly 500 particles on the pieces of tape 2 centimeters by  $2\frac{1}{2}$  centimeters. The next area of greatest concentration was the woods inside the city limits. There were roughly 400 particles present on pieces of tape collected. The area of lowest concentration was right inside the city limits. The number of particles present were roughly 300 particle

PROPOSED ALTERNATIVES FOR LIMITED ACCESS TO FALSE CAPE STATE PARK THROUGH BACK BAY NATIONAL WILDLIFE REFUGE. Mary Ann Sykes\* Lynchburg Col., Lynchburg, Va. 24501. In order to meet recreational needs identified in the Va. Outdoors Plan 1979, the Commonwealth of Va. is seeking limited access through Back Bay National Wildlife Refuge. At present, the park is accessible only by boating, biking, or hiking. Various proposals have been developed to obtain this limited access through the refuge. It is thought that the present policies and objectives of both the refuge and the park can be maintained by the exchange of land or right-of-way grants. These proposals are reviewed.

Preliminary Studies of Selected Heavy Metals in the Waste Waters of the Lynchburg Area in Central Virginia. Walter Younger,\* Regional Waste Water Treatment Facility, Lynchburg, Va. 24505. Analysis of 9 metals (Pb, Cd, Zn, Cr, Fe, Ni, Mn, Cu, & Ag) were performed on the Waste Treatment Facility's influents, settling tank overflows, effluent, and waste sludges and also on 6 local streams and the James R. to determine typical metal levels. The Facility influents are heavily contaminated in comparison to the Lynchburg streams and the river. Metal removals from liquid portions by quiescent settling were poor except for Pb. When properly operating relatively large amounts of metal are removed by accumulation in the biomass except in the case of Mn which showed 0% removal. Concentration of toxic metals in sludges is believed to be a cause of concern. To illustrate the potential danger, grass and cherry tomatoes grown in some aged sludge (excess 10 yrs) were compared with grass grown in uncontaminated soil. High metal levels were observed in sludge grown grass but levels in tomatoes were comparable to the control grass. Implications are that fruit producing plants may be safe to grow in sludge soil but caution is recommended in utilization of leafy type plants.

## Geology Section

RECRYSTALLIZATION FEATURES IN DEFORMED ANTIPERTHITIC PLAGIOCLASE, MONTPELIER ANORTHOSITE, HANOVER CO., VA., Elizabeth L. Beasley\*, Col. of William and Mary, Williamsburg, Va. 23185. Recrystallization features in deformed antiperthitic plagioclase of the Montpelier Anorthosite are related to deformation and hydration. Antiperthitic plagioclase, the dominant mineral and textural feature in the anorthosite is modified by recrystallization. As recrystallization occurs, irregular strips and patches of epitaxial remobilized plagioclase are formed. Albite and pericline deformation twins suggest that strain enhanced diffusion was responsible for the remobilization of the plagioclase. Myrmekite in the Montpelier anorthosite is unique for it occurs between non-perthitic plagioclase and antiperthite. In accord with the ideas of Becke, it is believed that the replacement of the potash feldspar component of antiperthite by non-perthitic plagioclase causes the generation of silica. The dissolution of potash feldspar lamellae near non-perthitic plagioclase grain boundaries and their association with quartz droplets is support for this interpretation. The generated silica accounts in part for the quartz content of the myrmekite and poikilitic plagioclase.

THE MID-PROVINCE STRUCTURAL FRONT BETWEEN FREDERICK CO. AND BUCHANAN, VA.: AN INTERPRETATION. Kenneth F. Bick, Dept. of Geol., College of William and Mary, Williamsburg, Va., 23185. The leading edge of the North Mountain-Staunton-Pulaski fault complex and discontinuous fold systems immediately west mark the Mid-Province Structural Front. Whereas the Allegheny Front essentially reflects faults ramping from Rome Fm. to Martinsburg Fm., the Mid-Province Front is thought to be the step-up of a sole fault in the Martinsburg, associated with less significant Rome to Martinsburg ramping expressed as the fold system; Front thrusts branch from the Martinsburg sole fault. Assumptions involved in serial cross sections constructed to test this hypothesis were: horizontal "basement" (Rome decollement), uninterrupted Cambrian-Mississippian sequence to the west, doubled Cambro-Ordovician sequence to the east. The structure fits this simple framework with the additional assumption of subsurface duplication of the Tuscarora-Oriskany interval. Sections cannot be balanced unless the decollement at the Martinsburg level originally continued across the Front; on the west, except where splays that presumably surface in Devonian shale belts are present, there has been no disruption of the stratigraphic sequence. The decollement served as the roof fault for thrusts that ramped from the Rome level and created the associated fold systems.

**EARTHQUAKE TECTONICS IN THE VIRGINIA APPALACHIANS.** G. A. Bollinger, Seism. Obs., Dept. of Geol. Sci., Va. Polytechnic Inst. & St. Univ., Blacksburg, Va. 24061. Earthquake activity in the Va. Appalachians varies considerably along strike. In the northeast, from Shenandoah Co. northward, there was a minor amount of activity in the 19th century but very little since then. In their central portion, centered about Bath Co., the Va. Appalachians have been virtually aseismic. The most seismically active portion has been at Giles Co. in the SW part of the state. There, the largest earthquake to have occurred in Va. and the second largest in the SE U.S., took place on May 31, 1897. It was a magnitude 5.8, Intensity VIII shock centered near Pearisburg and felt over some 725,000 km<sup>2</sup>.

This paper will present results obtained from recent (1978-1983) seismograph network monitoring of the Giles Co. locale. Analysis of the network data has defined a 40 km long, NE-trending zone. That trend puts the zone at a 20-30° disparity with the ENE-trending host southern Appalachians. The zone extends vertically from 5 to 25 km in depth with a dip that is very steep to vertical. The depth range puts the zone entirely in the basement and below the Appalachian decollement. Geological interpretation of these seismic results suggests that the seismogenic fault is probably a reactivated Iapetan fault.

**PARTIAL EXTRACTION OF METAL FROM MINUS 80 MESH STREAM SEDIMENT AND COATED PEBBLES NEAR AN UNMINED SULFIDE DEPOSIT.** T. L. Brown and G. D. Robinson, Dept. of Geology, James Madison Univ., Harrisonburg, VA 22807. Samples of fine-grained stream alluvium and pebbles with Mn-Fe oxide coatings were collected from streams associated with two small sulfide deposits near Andersonville, Va. Three partial extractants, oxalic acid, 10% H<sub>2</sub>O<sub>2</sub>, and EDTA, were used for sample leaching. Each sample type and reagent is evaluated for its anomaly enhancement potential and its ability to delineate the sulfide zones.

For both sediment and coatings, the utilization of ratioed data (metal/Mn or metal/Fe) following 10% H<sub>2</sub>O<sub>2</sub> digestion produces the greatest anomaly enhancement. Analyses of coatings consistently produce greater anomaly contrasts for Zn compared to sediment. Although anomaly contrasts for Cu are similar for both coatings and sediment, the sulfide zones are more precisely delineated by analysis of coatings.

If results of this study are generally applicable in Piedmont exploration, alluvial Mn-Fe oxides constitute a potentially superior sample medium which should be considered for future utilization.

**The Smith River Allochthon and Thin-Skinned Tectonics in the Virginia Piedmont,** by James F. Conley, Virginia Division of Mineral Resources, Charlottesville, Va. The Smith River allochthon is located in the S.W. Piedmont of Virginia and is correlated with rocks of the Inner Piedmont belt of North Carolina. It was thrust over rocks of the Sauratown Mountains anticlinorium and is preserved in a synformal structure between the Sauratown Mountains and Blue Ridge anticlinoria. This synformal structure plunges out both to the southwest in North Carolina and to the northeast in central Virginia. The southeastern edge of the allochthon is terminated against the Chatham fault, the border fault of the Danville Triassic basin, and its equivalent to the north. Because, in central Virginia, the southeast limb of the James River synclinorium is composed of rocks of the Smith River allochthon, the structure of this synclinorium is revised. Rocks in the core of the synclinorium are found to be not younger rocks, but older rocks that have been thrust from the east over younger rocks to the west. The structure is not a syncline, but a sequence of imbricate thrust sheets.

SEISMIC STRATIGRAPHY UNDER THE BLUE RIDGE AND PIEDMONT OF CENTRAL VIRGINIA, Wallace de Witt, Jr.\*, and Kenneth C. Bayer\*, U.S.G.S., Reston, Va., 22092. A U.S.G.S. common-depth-point reflection seismic profile along Interstate I-64 from the Valley and Ridge near Staunton, Va., east to the Atlantic Coastal Plain near Hampton, Va., reveals a regional mega-thrust system whose direction of transport is consistently onshore. Several well-defined seismic-stratigraphic units of regional extent are traceable from outcrops of named and mapped surface formations eastward beneath the Blue Ridge, Piedmont, and the contiguous part of the Coastal Plain. These units form a continuum that is locally cut by imbricate faults and thickened by subsurface duplication of beds. The combined Lynchburg, Swift Run, and Catoctin Fms. constitute the most extensive seismic-stratigraphic sequence, which extends from outcrops near Charlottesville in the eastern part of the Blue Ridge eastward in the subsurface to depths 50,000-55,000 feet beneath Richmond. The Chopawamsic Fm., the Maidens Fm. and Sabot Amphibolite of Glover and others, 1979, make up the 15,000-foot thickness of the eastern Piedmont thrust sheet, which underlies a wide area west of Richmond. Splay faults in the Hylas fault zone appear to cut out these units, and a thicker complex sequence of rocks identified as the Petersburg Granite is exposed at the surface near Richmond or is concealed beneath Coastal Plain sediments.

LATE ORDOVICIAN SEDIMENTARY TECTONICS OF THE VALLEY AND RIDGE IN VIRGINIA. Richard J. Diecchio, Dept. of Geology, George Mason Univ., Fairfax, VA 22030. An understanding of the eustatic and isostatic effects on sediment accumulation enables the interpretation of the often more localized tectonic effects. Sea level was probably falling during the early Ashgill, and remained low until the end of the Ordovician. During this low stand, the major portion of the Appalachian Basin was subsiding while sediments of the Queenston clastic wedge were accumulating. Late Ordovician subsidence patterns appear to have been simple in that portion of the basin that is now the Appalachian Plateaus. In the area that is now the Valley and Ridge, subsidence patterns appear to have been more complex.

Based on isopach and facies patterns, it can be determined that the Little North Mountain structural front coincides somewhat with each of the following: a boundary between the Reedsville shelf and the Martinsburg basin; the eastern limit of the Orthorhynchula brachiopod zone; the eastern limit of the Juniata redbeds; and an area of thinning of the Tuscarora Sandstone. It is inferred that the Little North Mountain front represents a tectonic feature that was active at least as early as the Late Ordovician.

PRE-TACONIAN DEFORMATION IN THE PIEDMONT OF THE POTOMAC VALLEY--Penobscotian OR Cadomian OR BOTH? A. A. Drake, Jr., U.S. Geol. Survey, Reston, VA 22092. Metamorphic rocks in the Potomac Valley comprise five stacked units, from highest to lowest, the Popes Head Formation which unconformably overlies all the others, the Piney Branch Complex, the Peters Creek Schist, the Sykesville Formation, and the Eastern Fairfax sequence. These rocks cannot be directly dated, but all are older than the Occoquan Granite that has been dated at about 560 Ma (Pb-U) and 494 Ma (Rb-Sr). Three fold phases have been recognized within the Popes Head. The Occoquan was probably synkinematically emplaced during the oldest phase, the Clifton, suggesting Early to Late Cambrian deformation. The Peters Creek and Eastern Fairfax sequence have had a much more complex geologic history. Poly-deformed migmatite and phyllonite olistoliths of Peters Creek Schist are found in the Sykesville Formation, showing that deformation predates the Sykesville, the younger Popes Head Formation, and Clifton-phase deformation. If the younger age of the Occoquan Granite is more nearly correct, the Clifton-phase deformation is probably Penobscotian (Late Cambrian). If the older age is correct, this deformation is probably Cadomian (latest Late Proterozoic - earliest Cambrian). Neither Penobscotian nor Cadomian deformation has been recognized in certifiable North American rocks, so this part of the Piedmont may be a suspect terrane.

**BEDDING PLANE DECOLLEMENTS AND LANDSAT LINEAMENTS: IS THERE A RELATIONSHIP?** Thomas M. Gathright, II and Charles B. Stanley, Va. Div. Mineral Resources, Charlottesville, Va. 22903. A correlation between deformation intensity along coal bed decollements and the proximity of LANDSAT lineaments was seen on the Pine Mtn. block in Wise Co., Va. Fracture studies defined two strong, near-normal, regionally extensive fracture systems of subparallel cleats, joints, cleavage and faults. Pervasive contractional faults in both fracture systems indicate both strike-parallel and strike-normal compression in the thrust sheet. The vertical, north trending, left slip Coeburn fault refracts fracture trends and parallels a major lineament suite. Using the Coeburn fault as a model, we propose that lineaments lying at 60 degrees to regional strike, like the Coeburn fault, are vertical zones of flexural slip folding within the systematic joint system. Flexural slip folding about vertical axes should produce differential horizontal displacement, oblique fracturing and deflection of fracture trends in the hanging wall of coal bed decollements beneath the flexural slip zones.

**OBSERVATIONS OF THE EOCENE DIKE SWARM, HIGHLAND COUNTY, VIRGINIA.** Karen J. Gray,\*, Dept. of Geol., George Mason Univ., Fairfax, VA., 22030, and U.S. Geological Survey, Reston, VA., 22092, and Richard J. Diecchio, Dept. of Geol., George Mason Univ., Fairfax, VA., 22030. Samples of intrusive rocks, known or presumed to be of Eocene age, have been analyzed by Instrumental Neutron Activation Analysis for minor elements. On the basis of these data and previous major-element data, the samples are found to form two main groups: basalts (containing about 50%  $\text{SiO}_2$ ) and rhyolites (containing about 70%  $\text{SiO}_2$ ). The rhyolites are centrally distributed within a larger area of basaltic outcrops. This bimodal and spatial distribution is analogous to volcanic systems associated with Cenozoic extensional tectonics in the western United States. The swarm of intrusions trends along the 38th Parallel, and apparently represents an eastward extension of the Shawneetown-Rough Creek fault zone. This linear zone extends from eastern Missouri, across southern Illinois, into western Kentucky, and is characterized by predominantly normal faults, igneous centers, and ore deposits. Activity along this fault zone dates from the Precambrian to the Recent. Our new minor-element data indicate a rift-related origin of the Highland County dikes. Relative concentrations of stable minor elements suggest minimal contamination by sialic crust.

**ORIGIN OF THE BALTIMORE MINE MANGANESE DEPOSITS, FORT VALLEY, VIRGINIA.** James H. Greene,\* Dept. of Geol., George Mason Univ., Fairfax, VA 22030, & Douglas Mose, Dept. of Geol., George Mason Univ., Fairfax, VA 22030. The Ridgely Sandstone on Three Top Mountain, Virginia contains manganese deposits which were mined early in this century. Samples from one of these mines, the "Baltimore Mine", were investigated using optical and chemical methods in an attempt to determine the orogenesis of this deposit. Comparisons are made between the trace element chemistry of this mine and other known deposits.

**EXPLORATION FOR URANIUM IN PITTSYLVANIA COUNTY, VA.** Christopher R. Halladay, Marline Uranium Corp., P.O. Box 1626, Danville, VA. 24543. In July, 1982, Marline announced the discovery of a major uranium deposit 6 miles northeast of Chatham. The orebody contains approximately 30 million pounds of uranium oxide at an average grade in excess of .20%  $\text{U}_3\text{O}_8$ , and larger quantities of lower grade reserves. The extent of the deposit was defined by 256 drill holes totaling 190,000 ft. The orebody lies within a shear zone adjacent to the Chatham Fault, which forms the western boundary of the Danville Triassic basin. The principal host rock is a protomylonitic augen gneiss that was probably derived from gneisses of the Fork Mountain Fm. and from Leatherwood Granite. The mineralization is hydrothermal and may be related to an Acadian orogenic event. In searching for this and other deposits, Marline has flown airborne radiometric, magnetic and VLF surveys. Surface exploration methods have included scintillometer, spectrometer, magnetometer and gravimeter surveys; soil and rock geochemistry; and soil radon gas measurements.

CONODONTS DOCUMENT CONTINUOUS TO INTERMITTENT DEPOSITION ACROSS THE LOWER-MIDDLE ORDOVICIAN BOUNDARY--NORTHERN VIRGINIA TO BELLEFONT, PA. Anita G. Harris\* & John E. Repetski\*, U.S. Geol. Survey, U.S. Nat. Mus. E-501, Washington, D.C. 20560. In the Valley and Ridge province, from Lexington, Va., to Tennessee, Middle Ordovician rocks of Chazyan and(or) early Blackriveran age disconformably overlie Beekmantown or Knox Group carbonate rocks that are consistently of latest Early Ordovician age. Physical evidence for this unconformity includes surfaces of considerable relief, solution features, and chert-pebble conglomerates. From Harrisonburg, Va., northward along the Allegheny Front in Pennsylvania, physical evidence for an unconformity between the dominantly Lower Ordovician dolostone sequence and the overlying Middle Ordovician limestones is generally absent. Karstification features and scattered chert-pebble lenses, however, occur locally in the upper several hundred feet of the Beekmantown Group. In this region, conodonts, virtually the only biostratigraphically diagnostic fossils in these rocks, record continuous deposition across the Lower-Middle Ordovician boundary which lies from 900 to 350 feet below the top of the Beekmantown Group. Because the porosity horizon(s) developed at the Lower-Middle Ordovician unconformity is often the target for explorationists, these new age and paleogeographic data significantly affect hydrocarbon and mineral exploration strategies.

CHEMICAL WEATHERING OF A HOMOGENEOUS CRYSTALLINE ROCK. Michael Hartley\* and Douglas Mose, Department of Geology, George Mason University, Fairfax, VA 22030. The Lynchburg Formation in southwest Virginia is a metasedimentary formation composed of an upper schist unit and a lower gneiss unit with amphibolite zones located at the base of both units. An amphibolite grade quartz-plagioclase-two mica gneiss of very uniform composition is located at the base of the Lynchburg. The parentage of the QPM gneiss is uncertain, but since a Rb-Sr isochron study of both the Lynchburg and the QPM gneiss indicates that both rocks experienced isotopic homogenization during Paleozoic metamorphism, it is likely that the QPM gneiss was a sedimentary or volcanic rock prior to metamorphism. A study of chemical variations in the QPM gneiss caused by weathering indicates that neither the B soil horizon or the C soil horizon is suitable for age determinations using the Rb-Sr whole-rock isochron technique.

USING COMPUTER PROGRAMS IN GEOLOGY: UNDERGRADUATE EDUCATION. Diana J. Holford\* & Peter G. Kimmel, Dept. of Geology, George Mason Univ., Fairfax, Va. 22030. Computer programs useful to students and teachers of undergraduate geology fall into five basic categories: performing long, repetitive, or complex calculations; storing and retrieving large amounts of data; presenting data in graphic (chart) form; simulating real-life events or activities; computer assisted instruction. Programs written in languages like BASIC, FORTRAN, and Pascal are listed in various indexes and periodicals; but because there are few educational geology programs available, you may have to write your own. Some suggestions for writing your own programs: choose the correct language for the type of program you are writing (e.g. BASIC is a good language for most applications, but not for data base programs); select a large enough (or small enough) computer to deal with your program; make your program easy to use by providing adequate documentation (manuals, comment or remark lines, and prompt lines).

PERVASIVE CATACLASTIC TEXTURES IN A FELSIC GNEISS UNIT WEST OF THE RICHMOND BASIN, VIRGINIA. Stephen C. Johnson\*, Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185. Structural and petrographic studies of the Mosely Felsic Gneiss of Reilly (1980) adjacent to the western border of the Richmond Basin show that the unit is heterogeneous in composition and has cataclastic textures throughout. The Mosely Felsic Gneiss, as mapped, has three primary rock types: felsic gneiss, amphibole gneiss and biotite gneiss. Felsic gneiss is dominant and has the best preserved cataclastic textures, ranging from ultramylonite to microbreccia. Three periods of deformation have been identified in the felsic gneiss. This unit may be correlative to the Hylas zone, a well defined cataclastic zone on strike to the north of the Mosely Felsic Gneiss.



DINOFLAGELLATE PALEOECOLOGY OF THE VIRGINIA COASTAL PLAINS. by Debby Kay\* Dept. of Geology, George Mason Univ., Fairfax, VA. 22032. Dinoflagellate assemblages from U.S.G.S. core samples in King George County, Virginia have been examined for possible paleoecologic indications of the Paleocene and early Eocene Coastal Plain Province. Formations sampled include the Aquia (Paleocene) and the Nanjemoy (early Eocene) and the Marlboro Clay which is sometimes present between the Aquia and the Nanjemoy. Paleoecologic interpretations are based on species dominance and diversity patterns. Initial comparisons show a correlation between the appearance of certain species and changes in the relative dominance and diversity ratios which suggest that environmental factors are primarily responsible for the cyst assemblages of the study section. Characteristic species of higher diversity suggest a more offshore environment; lower diversity figures appear to represent a near shore environment.

FOSSIL BONY FISH OF THE CHESAPEAKE GROUP, VIRGINIA AND MARYLAND. Peter G. Kimmel, Geology Dept., George Mason Univ., Fairfax, Va. 22030. Although teleosts have been known from the Chesapeake Group since the late 1700's, no comprehensive survey has been published. A preliminary list of specimens from the Smithsonian Natural History Museum, the Calvert Marine Museum, and private collections show that formations within the group contain: a sturgeon (Acipenser); a sea catfish (Arius); a bonefish (Paralbula); a wrasse (Prototoga); several mackerels (Acanthocymbium, Neocymbium, Cymbium); two swordfish (Istiophorus, Xiphas); a cod (Gadus); a porcupine fish (Diodon); an ocean sunfish (Mola); a black drum (Pogonias); a whiting (Menticirrhus); a tilefish (Lophotilus). The more complete articulated specimens appear to be from offshore muds, below wave base. Other fossils are isolated, abraded fragments from conglomerates or shell layers and suggest more shallow water deposition.

PENETRATION RESISTANCE OF THREE VIRGINIA SOILS. Stephen F. Maher\*, Dept. of Geol., James Madison Univ., Harrisonburg, Va. 22807. Penetration resistance is commonly used to indicate bearing strength in compacted soil masses. Most engineering specifications require that soil foundations in the field be compacted to maximum density at optimum moisture content. The purpose of this study was to measure penetration resistance of three common Virginia soils representing extremes in texture. Each soil was compacted at a range of moisture contents. Test results indicate that the penetration resistance of the three soils is greater on the dry side of the optimum moisture and maximum density and declines as moisture increases. It is concluded from this study that the maximum penetration resistance of many soils is reached when the compacted soil is on the dry side of optimum moisture and at lower than maximum density. Since virtually all construction specifications require soil foundations to be placed at optimum moisture and maximum density this study would indicate that such placement may not be at maximum bearing strength.

PREDICTING GEOLOGIC HAZARDS IN ADVANCE OF MINING. Marshall S. Miller\*, Geological Consulting Services, Bluefield, Virginia 24605. In the Appalachians, thick coal reserves with overall good mining conditions are becoming more scarce each year. With erratic and decreasing market conditions, the ability to define low-cost high-productivity reserves among the remaining complex coal measures is now a critical requirement for Appalachian coal producers.

Predicting geological hazards prior to mining offers the industry potential success for achieving low-cost mining. Among the applications are: depositional modeling; roof and floor rock mapping utilizing drill test data and underground reconnaissance; seismic surveys, geophysical logging; and remote sensing. Classification of lineaments in coordination with overburden and roof rock mapping appears to offer the most useful and productive geological tools for defining potential hazards in advance of mining. Case histories will be demonstrated for mining operations in Maryland, Virginia, West Virginia, and Kentucky.

### <sup>87</sup>Sr/<sup>86</sup>Sr EVIDENCE FOR PAN-AFRICAN TYPE GRANITES IN THE BLUE RIDGE.

Douglas Mose, Department of Geology, George Mason University, Fairfax, VA 22030  
The Pan-African orogenic belts in Africa are similar to the latest Precambrian geology of the central and southern Appalachians in that both appear to have involved the development of an ensialic basin in latest Precambrian time. In the Appalachians, the basin development is recorded by the Lynchburg Formation and similar sedimentary-volcanic units. Geochemical evidence indicates that this basin was initiated by rifting and the emplacement of peralkaline plutons about 690 m.y. ago. Although the Lynchburg and related units cannot be dated (no fossils; Paleozoic metamorphism has "reset" the isotopic chronometers), the closure of this latest Precambrian basin is marked by the emplacement of per-aluminous plutons about 600 m.y. ago. It appears that this depositional event which involved the Lynchburg and similar units preceded the opening of the Proto-Atlantic by a time interval similar to the interval between deposition of Appalachian graben sediments and volcanics of Triassic age and the opening of the modern Atlantic ocean.

### Rb-Sr AGE IS ORDOVICIAN FOR THE CATOCTIN METABASALT AND METARHYOLITE.

Susan Nagel\* and Douglas Mose, Department of Geology, George Mason University, Fairfax, Virginia, 22030. An 800 million year old age for the Catoctin and related formations (Rankin and others, 1969) is generated by discordant zircons and can not be correct, since Catoctin-type feeder dikes are found cutting the Robertson River pluton, and the pluton has an age of  $570 \pm 15$  million years. A Rb-Sr whole rock study shows that the Catoctin Metabasalts yield an isochron age of  $470 \pm 70$  million years (initial ratio  $^{87}\text{Sr}/^{86}\text{Sr} = 0.7039 \pm 0.0002$ ), and the Catoctin Metarhyolites yield an age of  $420 \pm 4$  million years (initial ratio =  $0.7118 \pm 0.0099$ ). A consideration of the ages, initial ratios and radiogenic growth of  $^{87}\text{Sr}$  suggests that the Catoctin was metamorphosed about 420 million years ago, and no more than 70 million years could have elapsed between the extrusion and metamorphism of the Catoctin. If this interpretation of the Rb-Sr data is correct, then the Catoctin was extruded no more than about 490 million years ago, and therefore is probably an early Ordovician unit.

### GEOCHEMICAL DISCRIMINATION BETWEEN THE NORTON AND WISE COALS, SOUTHWEST VIRGINIA

Jack E. Nolde\*, Virginia Div. of Mineral Resources, Charlottesville, Va., 22903

Chemical analyses of coal samples from the Norton and Wise formations provide a data base for discrimination. Using analysis of the volatile matter, fixed carbon, ash, total sulfur, iron oxide, titanium oxide and 11 trace elements, discriminant functions were calculated, and used to classify coals.

Using analyses of Mn, U, B, Fe<sub>2</sub>O<sub>3</sub>, Cu, in 38 coals, with 19 from above the Kennedy coal and 19 below the Kennedy coal gives a discriminant function with 84.2% probability of classifying a coal as upper or lower Norton. Analyses of VM, S, Ce, Co, Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, U, and V on 34 coals in each group gives a discriminant function with 82.3% probability as being a Norton or Wise coal.

The proximate and major and trace elements show that the upper Norton coals have a higher total S, B, Ce, Cu, Fe<sub>2</sub>O<sub>3</sub>, Ni and V, the lower Norton coals containing a higher Mn concentration. The Norton coals average higher in ash and Mn; the Wise coals are higher in B, Ce, Co, Ge, Fe<sub>2</sub>O<sub>3</sub>, Ni and V.

## NUMERICAL ANALYSIS OF GAMMA-RAY LOGS OF THE HINTON FORMATION, SW VIRGINIA

Jack E. Nolde\*, Virginia Div. of Mineral Resources, Charlottesville, Va., 22903

The Hinton Formation is a wedge of near-shore marine strata consisting of alternating siltstone, sandstone, and limestone beds in southwestern Virginia.

Fourier analysis of 31 gamma-ray logs of the Hinton indicate that there are significant differences in radioactivity among the wells. The gamma-ray logs were digitized, and Fourier coefficients computed, assuming a fundamental period of 24, for the first twelve harmonics. The coefficients were used to compute the discrete power spectrum square root (Cn), and then subjected to the Kruskal-Wallis test and discriminant analysis.

Discriminant analysis on the 12 Cn values yielded six harmonics as being significant difference indicators. The significance was tested with WILK'S lambda and Chi-Square statistic and indicates that the discriminant separates the Hinton Formation into two distinct groups. Use of the discriminant will result in correct group assignment approximately 90% of the time.

## ENVIRONMENTAL GEOLOGY OF FOUR MILE RUN J.V.O'CONNOR, Dept. of Earth and Life Sciences, Univ. of D.C., Washington, D.C. 20008.

A small Fall Zone drainage basin in Northern Virginia, once known for its flood impact, has numerous natural history events and geological processes to observe and investigate over a short linear distance. This small basin (20 sq. miles) provides an ideal case study illustrating a classic contrast between Piedmont and Coastal Plain land uses and associated hazards accumulating downstream. Among the measureable landscape processes are fall retreat, spring flow, run-off, tide cycles, terrace origin, slides and erosion. Research potential lies in mineral resources, metamorphism, structure, sedimentation, paleontology, agronomy and climatology. Social history still survives with Indian artifacts, mill-farm sites, mineral springs, road and rail right-of-way. A thirty million dollar flood control project, managed by a computer model, has increased property values, displaced the poor, but stopped the flooding. The tidal mouth supports an airport, marina, railyards, major highways, treatment plant, state boundary and parkland. This watershed is a living short course.

## GEOLOGY OF AN ALASKITE DIKE(?) EXPOSED SOUTHEAST OF CHARLOTTESVILLE, VIRGINIA.

Robert A. Russin\* and W. Cullen Sherwood, Dept. of Geol., James Madison Univ., Harrisonburg, Va. 22807. On the east flank of Monticello Mountain southeast of Charlottesville a felsic dike-like rock body crops out within the Catoctin Greenstone belt. In hand specimen the rock exhibits fine granular texture and rich pink color. Petrographic analysis shows a predominance of equigranular quartz (51.4%) and perthitic feldspar (34.7%) with minor magnetite (2.2%). Mineralogy and texture conform to the classical definition of alaskite. Field investigations indicate the rock body is tabular in shape, and trends parallel to the strike of the enclosing greenstone. While the origin of the rock is obscure the following evidence favors an igneous rather than a sedimentary origin; 1) other metasediments within the Catoctin are quartzites with obvious grain rounding and sedimentary structures, 2) sources for perthitic feldspar sediments are not found in the vicinity, 3) the level of metamorphism required to alter a sediment to alaskite would probably have metamorphosed the enclosing greenstone beyond the present greenschist facies, and 4) while no sedimentary structures were found in the alaskite, possible flow structures were observed.

## BROKEN-FORMATIONS OF THE PULASKI THRUST SHEET, NEAR PULASKI, VIRGINIA.

Art Schultz\*, Virginia Div. Mineral Res., Charlottesville, Va. 22903

Broken-formations (Hsu, 1974; Harris and Milici, 1977) occurring in the lower part of the Pulaski thrust sheet contain some of the most strongly deformed sedimentary rocks in the Valley and Ridge province of the Southern Appalachians. Deformation in this zone ranges from grain scale cataclasis to regional scale faulting. The broken-formations are distinguished from rocks structurally higher on the sheet and from rocks of the underlying Saltville sheet by: 1) a sharp increase in the variability of fold and fault styles; 2) greater ranges in fold plunges and dips of axial surfaces; 3) a low degree of preferred orientation of folds and faults; 4) an increase in the frequency of mesoscopic structures and 5) the presence of Max Meadows tectonic breccia. Structural analyses seem to indicate that deformation in the broken-formations is Alleghanian in age and that they formed under elastico-frictional conditions, possibly under elevated fluid pressures with temporally variant stresses and that lithology may have played an important role in localizing the broken-formations along the base of the Pulaski sheet.

CORONAS IN THE MONTPELIER ANORTHOSITE, HANOVER CO., VA. Ellen R. Stofan\*, Dept. of Geol., Col. Wm. & Mary, Williamsburg, Va. 23185. Two types of coronas were found in the Montpelier anorthosite, located in Hanover Co., Virginia. One type of corona formed around pyroxene, the other type around ilmenite or rutile. Coronas are common in anorthosites and related rocks. The structures **preserve** past chemical reactions in the rocks.

The pyroxene coronas typically have four shells. The pyroxene itself has been replaced by an amphibole and biotite pseudomorph. Rimming the pseudomorph is a shell of granoblastic biotite and quartz, a biotite mat, a garnet shell, and a zone of recrystallized plagioclase. The rutile and ilmenite coronas have rims of sphene, biotite, and possibly garnet. The formation of all of the shells can be accounted for by combining the minerals present.

The reactions to produce the coronas indicate that the deposit has gone through several stages of metamorphism. The coronas at Montpelier were probably produced as the anorthosite was subjected to retrograde granulite facies to amphibolite facies metamorphism, which supports the general theory that coronas are retrograde features (Griffin and Heier, 1973). (Supported by Col. of Wm. & Mary minor research grants)

ROCK AND MINERAL RESOURCES IN VIRGINIA. Palmer C. Sweet\*, Virginia Division of Mineral Resources, Charlottesville, Va. Mineral production in Virginia in 1982 was valued at \$1.57 billion, \$221 million less than 1981 due primarily to a DOE projected 5.8 million ton decrease in coal production. Rank of mineral commodities produced by total sales were: coal, stone (crushed and dimension), cement, lime, sand and gravel and natural gas. Virginia led the nation in the production of kyanite, and a feldspar marketed as "Virginia Aplite." Other commodities produced include clay materials, glass sand, gypsum, iron-oxide pigments, petroleum, by-product sulfur, talc, and vermiculite. Processing plants imported and prepared calcium aluminate cement, lithium carbonate, magnetite, manganese, mica, perlite, and vanadium pentoxide. Resources that may be important in the future include uranium, base and precious metals, tantalum and beryllium minerals, diatomaceous sediments, industrial silica and additional raw materials suitable for filler and extender uses. Potential waste material resources include flyash, by-product carbonate, diabase and granite fines, and high alumina (85%+) slag.

ALLOCHTHONOUS CLASTS OCCURRING IN THE CHOWAN RIVER FORMATION (UPPER PLIOCENE) OF SOUTHEASTERN VIRGINIA. Andrea E. Victor\*, Dept. of Geology, College of William and Mary, Williamsburg, VA 23185. Allochthonous clasts of Coastal Plain origin occur within the Chowan River Formation (Yadkin's beds=Upper Pliocene) near Yadkin in southeastern Virginia. Ellipsoidal, discoidal and irregular clasts ranging in size from 1 to 50 cm are distributed sporadically throughout the Chowan River. The mineralogy and internal fabric were examined with x-ray diffraction, electron microscopy and in thin section. Goethite(?), angular quartz, calcite(?), mica and ilmenite(?) occur in the dense fine-grained matrix of the iron-rich clasts. All clasts exhibit fossate, dimpled or shell impressed oxidized surfaces. Locally derived from weathered Yorktown sediments, the clasts were reworked into the Chowan River Formation during the accompanying marine transgression. The presence of Yorktown derived clasts substantiate the presence of the disconformity between the Yorktown Formation and the Chowan River Formation.

THE EFFECT OF ACID RAIN ON THE WEATHERING OF SEDIMENTARY ROCKS INDIGENOUS TO ROCKBRIDGE COUNTY, VIRGINIA. Richard W. Young, Daniel W. Armstrong, Robert T. Grauer Jr., Michael A. Pleva, Scott S. Prysi, James K. Shillington, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. The purpose of this research project is to obtain data concerning the acid rainfall in Rockbridge County and to apply this data to understand how acid rainfall may accelerate the chemical weathering of limestones, dolomites, and sandstones within the county. Lab results may even be useful in predicting geophysical changes due to acid rain. We devised a simple experiment to measure the chemical weathering of various rocks. Rock samples are collected from lithologically distinct outcrops and fractionated into particles of about 2.0 mm in diameter. Synthetic acid rain is made from deionized water by adding sulfuric acid and sodium bicarbonate as necessary to obtain waters of pH 3.0, 4.0, 5.0, 6.0, 7.0, and 8.0. Each of the rock samples is then equilibrated with each of the samples of synthetic acid rain. An Atomic Absorption Spectrometer is then used to determine the concentrations of  $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ , and  $\text{Fe}^{+3}$  in these solutions. The results should indicate whether or not acid rain speeds the chemical weathering of rocks. Meanwhile, we have collected rain to determine the acidity of rainfall in the Rockbridge County area.

## Materials Science Section

IN-SITU DEPOSITION AND MELTING OF SUBMICRON INDIUM-TIN ALLOY PARTICLES. G. L. Allen\*, and W. A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901 Although the TEM study of the melting point of small, single component, metal particles has been of interest for some time, little is known about particles of binary compositions. For the In-Sn system, particles in the 5 to 50 nm range of diameters were co-vapor deposited onto supported carbon films in vacua of  $5 \times 10^{-6}$  torr to  $10^{-7}$  torr for in-situ depositions. Evidence has suggested that the liquidus line of the bulk phase diagram is shifted overall to lower temperatures for particles of high and low in concentrations. In addition, the composition extent of the single phase regions of the phase diagram are displaced depending on the size of the particles. Dark field microscopy and diffraction patterns reveal that amorphous particles are formed for some ranges of composition as determined by X-ray energy dispersive spectroscopy. These nearly coincide with at least two of the three two-phase regions of the bulk phase diagram at room temperature. Particles having compositions which correspond to the single phase regions show normal crystalline structures. In addition, the presence of internal boundaries can be resolved in particles as small as 10 nm in diameter, suggesting the presence of interphase boundaries.

CAN NUCLEATION THEORY BE APPLIED TO SECOND ORDER TRANSFORMATIONS? R. E. Barker, Jr., Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. According to nucleation theory, for a single chemical constituent, local density fluctuations will lead to the formation of a small nucleus of  $\beta$ -phase within an  $\alpha$ -phase matrix if the temperature is less than  $T_t^\circ$ , the normal transition temperature for  $\alpha \rightleftharpoons \beta$ . An interfacial free energy  $\gamma_{\alpha\beta}A_{\alpha\beta}$  will oppose the enlargement of the nucleus and a bulk free energy  $gV_\beta$  will encourage growth, where  $g = (G_\beta - G_\alpha)/V_\beta$  and  $V_\beta$  is the transformed volume. In the standard treatment  $\Delta G = \Delta H - T\Delta S$  is approximated, for undercooling  $\theta = T_t^\circ - T$ , by  $\Delta H \approx \Delta H_t^\circ$  and  $\Delta S \approx \Delta H_t^\circ/T_t^\circ$ , giving  $\Delta G \approx \Delta S_t^\circ \cdot \theta$ . In the present approach  $g$  is taken as a power series,  $g(\theta) = a_0 + a_1\theta + a_2\theta^2 + \dots$ . Thermodynamic relations,  $S = (\partial G/\partial T)_P$ , etc., lead to  $a_0 = 0$ ,  $a_1 = -\Delta H_t^\circ/V_\beta$ ,  $a_2 = (\Delta C_p/T_t^\circ V_\beta) + 2\alpha_\beta \Delta H_t^\circ/V_\beta T_t^\circ$ , ... . This approach not only gives correction terms for first order transformations, it also provides the formalism for extending the theory to higher order transformations. For example, for a second order transition it is predicted that  $r^* \approx 2\gamma V_\beta T_t^\circ/\Delta C_p \cdot \theta$ , for the critical size of a spherical nucleus.

X-RAY FLUORESCENCE SPECTROMETRY. Robert A. Bayles, Code 6312 NRL, Washington, DC 20375. X-ray fluorescence spectrometry (XRF) is a technique to perform non-destructive chemical analysis. At the Naval Research Lab XRF is used to help characterize materials to be used in research projects, to identify the material in a component which is the subject of a failure analysis, to re-identify samples having different compositions which were inadvertently mixed up, and to sort scrap. The XRF technique involves exciting electrons within the atoms in a material using a source of x-rays, detecting the x-rays produced as the atoms relax, determining the intensity (number of photons) produced as a function of their energy or wavelength, interpreting this spectrum, and, for quantitative results, comparing this spectrum with the spectrum of a standard material of similar composition. The instrument which is discussed is a commercial instrument which, due to thorough engineering, combines high analytical performance and flexibility with convenience and safety. Topics discussed include advantages and disadvantages of XRF, x-ray sources, wavelength and energy dispersion, x-ray detectors, multichannel analyzers, specimen preparation, qualitative analysis, and various approaches to doing quantitative analysis.

ANALYZING FRACTURE SURFACES BY PHOTOGRAMMETRY. J. I. Bennetch, Metallurgy Laboratory, Reynolds Metals Company, Richmond, Va. 23261. Photogrammetry, "a science of making reliable measurements by the use of usually aerial photographs in surveying and mapping," is also a useful metallurgical tool to characterize microscopic topological features. For instance, in fractography, contour maps accurately portraying three dimensional features of fracture surfaces can be constructed by photogrammetry. In addition, photogrammetry can be employed to correlate certain bulk tensile and fatigue properties with microscopic properties. Fracture surface dimple size, spacing and depth, as determined by photogrammetry, can be related to fracture toughness. Moreover, dimple size is also a function of the stress intensity factor in tensile specimens and the crack growth rate in fatigue specimens.

THE GROWTH OF III-V SEMICONDUCTOR MATERIALS BY ORGANOMETALLIC CHEMICAL VAPOR DEPOSITION. Ivan O. Clark, A. L. Fripp, R. K. Crouch, and W. J. Debnam, NASA Langley Research Center, Hampton, VA, 23665. Vapors from organometallic compounds such as trimethyl gallium, triethyl indium, and trimethyl bismuth can be used with hydrides such as arsine and phosphine of the group V elements as sources for the growth of epitaxial layers of III-V semiconductor materials. The semiconductor layers produced by this organometallic chemical vapor deposition technique have many novel applications in electronics and electro-optics. An overview of ongoing research in this budding field will be presented along with a description of some of the advantages and the unique problems of this technique.

**FRICTION AND WEAR OF AN ION-IMPLANTED Co-BASED ALLOY.** S.A. Dillich\* and I.L. Singer\*, Code 6170, Naval Research Laboratory, Wash., DC 20375. The effects of ion implantation on the tribological behavior of a centrifugally cast, cobalt-based alloy (50 Co, 31 Cr, 12.5 W, Stoddy 3) have been investigated by friction tests and wear scar analysis. The kinetic coefficient of friction,  $\mu_k$ , was measured on implanted and nonimplanted Stoddy 3 disks using a ball on flat geometry during low speed (0.1 mm/sec), dry sliding contact. High friction coefficients ( $\mu_k \approx 0.6$ ) observed for alloy/Stoddy 3 couples coincided with the formation of debris with the same composition as the softer of the mating alloys in the wear scar. Much lower  $\mu_k$  values ( $\mu_k \approx 0.25$ ) were measured on titanium implanted surfaces. Auger spectroscopy revealed that vacuum carburization of both carbide and matrix phases of the Stoddy alloy occurred during titanium implantation. Implantation of the Stoddy alloy with nitrogen did not result in low friction during dry sliding tests.

**THE DUCTILE FRACTURE OF C.P. TITANIUM.** Marjorie A. Erickson and H.G.F. Wilsdorf, Dept. of Mat. Sci., The Univ. of Va., Charlottesville, Va. 22901. The ductile fracture of C.P. titanium was studied, with samples of varying grain sizes, using tensile testing techniques, statistical evaluations, and stereo photographic techniques. Statistical studies of grain size, dimple size, intertriple point and interdimple spacings were used to aid in the determination of microvoid initiation sites. The stereo photographic techniques were used in conjunction with the Scanning Electron Microscope to study microstructural fracture surface characteristics. Stereo techniques such as contour maps and relative height profile lines were utilized in matching dimples on opposing fracture surfaces. These quantitative techniques enabled crack opening modes to be determined and thus allowed for the qualitative evaluation of local stresses and stress state variations throughout the fracture surface. Knowledge gained of the stress states that contribute to fracture aid in the study of void growth mechanisms. (Supported by the Office of Naval Research)

**A TEM STUDY OF THE PEARLITE-RETAINED AUSTENITE INTERFACE.** S. A. Hackney\* and G. J. Shiflet\*, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. An Fe-C-Mn alloy was studied to ascertain the possible role of crystallography during the pearlite reaction. There are two major theories of pearlite formation and growth in ferrous materials. The first, due to Hull-Mehl, depends heavily on crystallographic effects upon nucleation and growth kinetics of both ferrite and carbide phases. The second, which is generally accepted over that of Hull-Mehl, is due to Hillert. Hillert considers crystallographic effects as secondary and "fairly unimportant", and relies instead upon the gradual evolution of structure-insensitive, cooperative diffusional growth of the two phases in the formulation of this theory. However, recent demonstrations of partial coherency across apparently ill-matching fcc:bcc interphase boundaries by computer simulation and direct TEM evidence has given impetus to the emerging viewpoint that disordered boundaries may be less prolific than previously thought. We will report on our attempts to reanalyze both theories using high resolution transmission electron microscopy as the primary tool. The effect of crystallography will be noted as well as its relative importance during the pearlite reaction.

APPLICATION OF A MAXIMUM-STRESS CRITERION TO CRACK PROPAGATION IN NEUTRON AND He-IRRADIATED STAINLESS STEEL. T. Hanamura\* and W. A. Jesser, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. To better correlate the relationships among neutron and helium irradiation-induced microstructure, tensile test condition, and the mechanism of intergranular fracture and flow localization, crack opening mode (Mode I and II) was determined as a new crack propagation parameter and correlated with the local tensile condition near the crack tip by using in-situ HVEM tensile testing of austenitic stainless steel microspecimens. It was found that all grain boundary sliding was observed to be caused by a nearly Mode I crack reaching a grain boundary at an angle near  $90^\circ$  and initiating Mode II cracking at the grain boundary. To explain this behavior, a maximum-stress criterion was developed. Mode II failure was hindered and Mode I cracking was favored by neutron and helium-irradiation, but Mode II cracking could be restored by post-irradiation annealing in the core of helium irradiation. Intergranular failure was observed in the thick regions (25  $\mu\text{m}$ ) of helium-irradiated specimens even though the penetration depth of the 80 keV helium was less than 0.5  $\mu\text{m}$ .

MICROWAVE ABSORPTION OF FIBERGLASS COMPOSITES. Marvin Hass, Dept. of Physics, George Mason Univ., Fairfax, Va. 22030, & Naval Research Lab., Washington, DC 20375, & T.F. Francavilla, Naval Research Lab., Washington, DC 20375. Fiberglass composites generally consist of glass fibers and organic binders. By studying the temperature dependence of absorption at 10 GHz, it is possible to separate the contributions of each of these components. The "glassy" component is typical of many amorphous materials in being essentially temperature independent in the lighter range and very dependent in the 10-100K region. On the other hand, the "resin" component is temperature dependent near ambient. Its behavior appears quite similar to that of two-phonon difference band absorptions in simple cubic crystals. The results will be discussed in terms of current theories of microwave absorption in glasses and crystals. (Supported by the Office of Naval Research.)

STUDIES OF THE EFFECTS OF MOISTURE SORPTION ON ELECTRICAL CONDUCTION IN ION-DOPED POLYMERS. J. A. Hawk\*, D. Y. S. Chen\*, and R. E. Barker, Jr., Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. Previously Barker, Chen, and Huang have examined the process of charge transport in rigid rod polymers such as poly(p-phenylene benzobisthiazole), or PPBT, by measuring two types of transient currents. The PPBT is an extended chain aromatic hetero-cyclic polymer which exhibits both a gradual current decay over long periods of time, as well as large jumps in the relative current (i.e.,  $\Delta I/I_{\text{min}}$ ) when the PPBT sample is subjected to increases in relative humidity from essentially dry conditions. Experiments were conducted on PPBT samples doped with various solutions of  $\text{LiCl}$ ,  $\text{NaCl}$ ,  $\text{CaCl}_2$ ,  $\text{LaCl}_3$ , etc. In addition, undoped PPBT fibers were also tested, against which the doped results were compared. In the present work our goal has been to see if the transient current phenomena curve is distinguishably different for different types of polymers, or if there was something unique about the rigid rod polymers. Additional experiments have been performed on fibers of nylon 6,6 and polyethylene (PE) in both the doped and undoped form for a variety of experimental conditions. The most interesting general result is that each material appears to have its own characteristic type of  $\Delta I/I_{\text{min}}$  curve.

NDE ENGINEERING. Amos E. Holt, Babcock & Wilcox Company, Research & Development Division, Lynchburg Research Center, P. O. Box 239, Lynchburg, Va. 24505. This paper discusses the expanding field of Nondestructive Evaluation Engineering (NDE) in industry. This is not currently a separate discipline in academia, however, NDE uses the basic principles developed in classical engineering disciplines. NDE provides a mechanism for determining the remaining life of a component, its fitness for use and its ability to perform the desired function without rendering the component useless.



TRANSIENT DIELECTRIC PROPERTIES OF POLYMER-DILUENT SYSTEMS. C.-C. Huang\* and R. E. Barker, Jr., Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901

Recent work by Chen and Barker has provided persuasive evidence that a useful extension of the "weak electrolyte" model (of Barker and Sharbaugh) to the case of anisotropic polymer systems is possible. In continuing our studies of this and other more general features of transport mechanisms in polymers, quantitative information was needed for the dielectric permeativity tensor ( $\chi_{ij}$ ) and for its variation with temperature, frequency, and the concentration of various diluents and dopants. The present work relates some of the experimental approaches undertaken with these goals in mind and in particular addresses the relevant fact that during diffusion of a diluent into a polymer, the system is inhomogeneous and the effective average dielectric properties ( $K'$ ,  $K''$ , or  $\tan \delta = K''/K'$ ) have a time dependence which is related to the diffusion coefficient. A combination of dielectric cells (including a liquid immersion cell) and bridge techniques have been applied to examine PMMA, PS, PTFE, and PPBT (polyparaphenylene benzobisthiazole), in addition to a quartz standard.

A MICROSTRUCTURAL STUDY OF DUCTILE FRACTURE OF AN ALUMINUM COPPER ALLOY. David D. Makel\* and H. G. F. Wilsdorf, Dept. of Mat. Sci., Univ. of Va. Charlottesville, Va. 22901. The ductile fracture of an Aluminum-1.79w/oCopper alloy has been studied. Large and small polycrystalline tensile samples, heat treated to contain a solid solution, G.P. zones, and  $\theta'$  precipitates were strained to fracture and observed with scanning and transmission electron microscopes. Using stereo microscopy, the fracture surfaces of the bulk samples have been characterized with a special emphasis on analysis of the ductile dimples. This is used to determine the local modes of the crack opening and to gain insight into the nucleation, growth, and coalescence of the voids. Post-fracture TEM and STEM studies of the ligament remnants show the crystallography and general configuration of the final separation. These results, with related research, have been used to formulate a model of the final separation process. (Supported by the Materials Division of ONR.)

TRANSVERSE STRENGTH IMPROVEMENTS IN METAL MATRIX COMPOSITES. A. Y. Teng\* and F. E. Wawner, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. Tensile tests of SiC monofilament reinforced aluminum composites show transverse strengths less than 4000 psi. This strength is lower than the matrix strength and is closely related to SiC/Al bonding limitations. One solution to this problem is to make hybrid composites using a smaller and different type of fiber to reinforce the transverse direction without adversely affecting axial properties. The fibers used are the continuous Nicalon and FP fibers with a diameter range of 10-30  $\mu\text{m}$ . Results showed improvements in the composite transverse strengths. However, some problems were encountered which limited performance to that predicted by the rule-of-mixture.

## Medical Sciences Section

FUSION OF BIOMEMBRANES BY DIVALENT CATIONS, Kenneth Barfield\*, David Bevan, Department of Biochemistry, VA Polytechnic Institute, Blacksburg, VA 24061. A number of biological and cellular processes involve the fusion of biomembranes, but these fusion events are not well understood. The ability of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  to fuse phospholipid vesicles has been documented, but no such work has been done with the divalent cations  $\text{Zn}^{2+}$ ,  $\text{Cd}^{2+}$ , and  $\text{Hg}^{2+}$ . Resonance energy transfer between the fluorescent phospholipid analogues N-NBD-phosphatidylethanolamine and N-(lissamine Rhodamine sulfonyl)phosphatidylethanolamine can be used to assay fusion in vesicles containing the labelled phospholipids. In studies with small unilamellar vesicles composed of dipalmitoyl phosphatidylcholine (DPPC) and bovine brain phosphatidylserine (PS) it was found that the divalent cations caused fusion of the vesicles with the relative effectiveness being  $\text{Zn}^{2+} > \text{Cd}^{2+} > \text{Ca}^{2+} > \text{Mg}^{2+} \sim \text{Hg}^{2+}$ . In addition it was found that fusion occurred with as little as 20% PS in the vesicles, which is considerably lower than has been previously reported.

ANATOMY AND PSYCHOPATHOLOGY OF LARYNGEAL MUSCLE VOICE VIBRATIONS AND INTERPRETATIONS OF NORMAL AND NON-NORMAL STRESS REACTIONS. John C. Bartone, Department of Research, American Health Research Institute, Ltd., Annandale, Va. 22003. Normal and non-normal voice vibration stress reactions have not been completely elucidated. In known reactions, as practiced today, emphasis is limited, rigid and dogmatic. Stress reactions produce more than "innocence", fight or flight stress. Psychopathology is greatly inherent in parameters as stress resultant in "freeze", "feint", "feign" or animal acts as "die on the spot", equal to human hysteria, silent or otherwise. Such parameters highly complicate human experimentation. In addition ego-status, academic shock, fear of failure, other syndromes lessen validity of such conclusions for science, medicine or law. Inherent psychopathology of stress reactions persistently remains. Psychodiagnostic profiles appear necessary to increase validation.

L-LACTATE DEHYDROGENASE IN MITOCHONDRIA? R.B. Brandt, E.S. Kline, S.B. Tinsley\*, K.S. Rogers, E.S. Higgins, M.G. Waters\* and H.R. Seibel, Depts. of Biochemistry and Anatomy, Med. Col. of Va., VCU, Richmond, Va. 23298. Experiments on catabolism of D- and L- lactate by us, indicated that some L-lactate oxidation was taking place in the mitochondria. Mitochondrial and cytosolic fractions from rat brain, kidney, heart and liver were assayed for  $\text{NAD}^+$  dependent L-lactate dehydrogenase (L-LDH), cytochrome oxidase (cyt ox) and phosphoglucosmutase (PGM). PGM was used as a marker of mitochondrial contamination by cytosol and cyt ox was used to determine contamination of cytosol by mitochondria. The % LDH activity (mito/cytosol) on a wet weight basis was: liver 1.8; kidney 0.8; heart 0.5; and brain 1.2. From activity measurements of PGM in mitochondria there was no contamination by cytosol except in brain preparations. Both by PGM activity and EM, brain mitochondrial samples were contaminated with cytosolic components. Skilleter and Kun (1974) had shown L-LDH in liver mitochondria and we extend this finding to kidney and heart. Isozyme patterns are not the same for all tissues in the cytosolic and mitochondrial fractions. Respiratory control studies showed that oxidation of L-lactate oxidation was coupled to phosphorylation. (Supported by funds from NRCR and Univ. Grant-in-Aid, VCU).

**CADMIUM METABOLISM BY RAT LIVER SINUSOIDAL CELLS.** Thomas J. Caperna\* and Mark L. Failla, Dept. of Biochem. and Nutr., Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The metabolism of Cadmium (Cd) was investigated in rat liver sinusoidal cells isolated by collagenase dispersion and purified by centrifugal elutriation. Initial studies demonstrated that both Kupffer cells (KC) and endothelial cells (EC) accumulated significant amounts of Cd following injection (S.C.) of the metal salt (15 mg Cd/Kg body weight). When metallothionein (Mt) was assayed in cells isolated from control rats, low levels were present in KC, EC and hepatocytes (HC). Cd injection significantly increased Mt levels in all liver cell types; however, EC contained almost twice as much Mt/mg cell protein as KC and HC. Cd transport and metabolism by KC and EC was studied *in vitro* using primary monolayer cultures. The results confirmed that EC have a greater capacity to accumulate Cd than KC. These data indicate that the cells lining the sinuses of liver have a significant role in the metabolism of trace metals and the handling of toxic heavy metals. (Funded by NIH AM 363941).

**COMPUTER ANALYSIS OF SPECTRAL ABSORBANCES SEPARATING RATS FED 4%, 15%, OR 40% PROTEIN AND STRESSED BY RESTRAINT OR NOISE.** Germille Colmano, and R.W. Berlien, Coll. Vet. Med., Div. Vet. Biol. & Clin. Stud., & Gary Nunn, Computing Resources, VPI&SU, Blacksburg, VA 24061. Rats (21 day old) were equilibrated 1 week and pair-fed on a diet containing 4% casein. Then, the daily intake of 15% and 40% casein fed rats was adjusted so that each animal received the same daily ratio by weight. Immobilization or noise-stress from 36 to 41 days of age was finally added. Data on the level of several protein components of blood plasma, collected before and after stress, and representing only 1/3 of the data available for analysis, are presented. The results indicated that this technique successfully distinguished several different blood plasma proteins, differentiating across animal groups the 3 different blood protein levels, which corresponded to the 3 levels of casein fed to the rats. The matrix of F ratios for the 3 levels of protein before stress indicated a clear separation of groups. Also, a classification summary and F ratios for the stressed versus the non-stressed animals indicated the possibility of differentiating blood spectra between these groups.

**DEVELOPMENT OF A RAT MODEL FOR COMPUTER-RECORDED SCIATIC-NERVE SIGNALS (BEFORE INJURY) TO ASSIST REPAIR USING METAL (Na, K, Ca) MONOLAYERS COATED SUTURES.** Germille Colmano, and J.M. Gregg, Div. Vet. Biol. & Clin. Stud., Coll. Vet. Med.; W.E. Schwab, Dept. Biol.; D.J. Schneck, Biomed. Engr.; W.G. Herbert, Cardiac Rehabil.; and C.D. Berlien, Anaerobic Micro., VPI&SU, Blacksburg, VA 24061. A trifascicular sciatic nerve segment (15 mm) of rats was exposed at midpoint between spinal chord and knee, and its action potential, from bipolar stimulating-recording electrodes, was computer recorded. After epineural decompression, an 8 mm length of nerve was resected from both sides. The counter-lateral sides were grafted and allowed to spontaneously degenerate and/or regenerate. The right side was sutured with 90° nylon Ethicon and the left side was sutured with 90° reabsorbable (polygalactine) Vicryl microsutures coated with monomolecular layers of metal (Na, K, Ca) stearate films. Initial recordings of the electromagnetic field potentials on the left and right sciatic nerve, and recordings after two months indicate the feasibility of a computer-coordinated system.

CHLORDEONE\* (CD) EFFECTS ON HEPATIC MICROSOMAL BENZO a PYRENE (BP) METABOLISM L.S. Crouch and R. E. Ebel, Dept. Biochem., Virginia Tech, Blacksburg, VA 24061 CD, a polychlorinated hydrocarbon pesticide, induces cyt P-450. P-450 metabolizes PAH's such as BP to potent carcinogens and thus possible alterations in BP metabolism as a result of CD exposure are of concern. CD treatment of rats increases P-450 up to 2.7-fold compared to 2.6- and 1.6-fold increases, respectively, for phenobarbital (PB) and 3-methylcholanthrene (3-MC). BP metabolism measured by 3-hydroxy BP production (AHH) per nmol P-450 was 40, 40 and 270% of control values for CD, PB, and 3-MC microsomes, respectively. *In vitro*, 7,8-benzoflavone activates AHH in control, CD and PB microsomes but inhibits 3-MC. CD, *in vitro*, inhibits AHH in control and CD microsomes to a comparable degree based on total CD levels. PB microsomes are less sensitive and 3-MC insensitive to CD. Total BP metabolism is similar for control and CD microsomes. The data are consistent with similarities in the cyt P-450 pools of hepatic microsomes isolated from control and CD treated rats.

STIMULUS/SECRETION COUPLING IN HUMAN LEUCOCYTES: A KINETIC ANALYSIS. Robert W. Dougherty\* and Richard J. Freer\* Dept. of Pharmacol., Med. Col. of Va., Richmond, VA 23298. Secretion from DMSO stimulated HL-60 promyelocytic leukemia cells elicited by CHO-Met-Leu-Phe (fMLP,  $10^{-7}$ M) is rapid ( $t_{1/2} < 5$  sec) and accompanied by enhanced turnover of inositol phospholipids (IP) and phosphatidic acid (PA). In cells prelabelled with  $^{32}$ P, fMLP ( $10^{-7}$ M) elicited rapid (within 5 sec) decreases in radioactivity associated with phosphatidylinositol and phosphatidylinositol-4,5-bis phosphate with simultaneous increases in the labelling of PA and phosphatidylinositol-4-phosphate. Binding of fMLP had not reached steady-state conditions by 30 sec-a time when secretion and relevant lipid changes are complete-suggesting that only partial occupancy of receptors is sufficient to elicit maximal secretion. Based on the appropriate kinetics and agonist concentration dependency of both parameters measured, we conclude that IP and PA turnover may be key links in events coupling receptor occupancy and secretion. (Supported by the MCV Periodontal Research Ctr. and the Cystic Fibrosis Fndn.)

CHANGES IN SPEED-RELATED PROPERTIES OF SINGLE MOTOR UNITS IN THE CAT PRODUCED BY FATIGUE. L. Dubose\* and H.P. Clamann\* (Sponsor: J.L. Poland) Dept. of Physiol. and Biophys., Med. Col. of Va., Richmond, Va. 23298. Motor units typically discharge at rates (30-60 per sec.) well below those required to produce fused tetani and maximum tension; yet in man maximum contractions of muscles are readily produced. To examine this paradox, single motor units of cat gastrocnemius were studied. Twitch contraction time, half-relaxation times of twitches and of unfused tetani, and rate of rise of tetanic tension were measured at the onset and at later times during repeated phasic contractions. Phasic contractions were produced by trains of 13 stimuli at 40/sec. repeated every second. Fast motor units slowed progressively as shown by all above measurements; slow motor units increased their speed. We conclude that the dynamic properties of motor units change during contraction to reduce the differences between the fastest and slowest. Fast units can slow enough to produce maximal fused tetani when driven at 40-60 pulses/sec. (Supported by an N.S.F. Fellowship to L.D.)

SYNTHESIS AND-CHROMATOGRAPHY OF PYROGALLOL AND ITS SULFATE ESTERS. D. M. Dulik\* and W. H. Soine, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA 23298. Pyrogallol (1,2,3-benzenetriol, PY) is a polyphenol of both industrial and pharmacological importance. Studies on its metabolic fate have been limited. Sulfate esters of PY and 3-methoxycatechol (3MC) were prepared by reaction with pyridine-sulfur trioxide in pyridine at  $-20^{\circ}\text{C}$ . Optimal reversed-phase HPLC separation of these sulfate esters was achieved by addition of an ion-pairing agent (di-n-octylamine or tetra-n-butylammonium hydroxide) into the mobile phase. Retention behavior was found to be highly dependent upon both the type and concentration of pairing agent. Determination of the presence of PY and 3MC sulfate esters as urinary metabolites was accomplished by ion-pairing HPLC.  $^3\text{H}$ -PY was administered to a rat as a single dose (25 mg/kg, ip); 75% of the radioactivity was excreted in the urine after 12 hours. HPLC separation of urine samples showed the presence of PY mono- and disulfate esters, 3MC sulfate ester, and two other more polar metabolites: no free PY was detected.

THE BROAD-HOST RANGE STREPTOCOCCAL PLASMID pIP501: IDENTIFICATION OF PLASMID-ENCODED PROTEINS. R.P. Evans, Jr. and F.L. Macrina. Department of Microbiology and Immunology, Virginia Commonwealth University, Richmond.

The conjugative streptococcal resistance plasmid pIP501 (30 kb) encodes resistance to chloramphenicol and erythromycin ( $Em^r$ ). Using recombinant DNA methodologies, sequences from a cryptic multicopy plasmid, pVA380-1, were substituted for the pIP501  $Em^r$  determinant in vitro. The resulting recombinant plasmid which was recovered in transformed *S. sanguis* cells and designated pVA797 retained conjugal transfer ability ( $Tra^+$ ). Conjugal transfer deficient ( $Tra^-$ ) deletion derivatives of pVA797 were obtained in vivo. The entire pVA797 molecule and  $Tra^-$  deletion derivatives were separately cloned into the *E. coli* plasmid vector pOP203( $A_2^+$ ). These chimeric plasmids segregated into minicells where they directed protein synthesis.  $Tra^-$  derivatives of pVA797 were missing some polypeptides encoded by pVA797.

NAEGLERIA FOWLERI CYTOPATHOGENESIS FOR RAT NEUROBLASTOMA CELLS. D. E. Fulford and F. Marciano-Cabral. Department of Microbiology and Immunology, Virginia Commonwealth University, Richmond, Va. 23298. Naegleria fowleri nN68 (ATCC-30894), maintained in axenic culture for over 10 years, demonstrates a cytopathic effect for rat neuroblastoma (B-103) cells. Cytopathogenicity is measured by the specific release of  $^{51}Cr$  from radiolabelled B-103 cells. The release of radiolabel is correlated with, but is more sensitive than scoring cytopathogenicity by light microscopic examination of target cell cultures. Live amoebae and amoebic lysates induce a range of specific release of radiolabel of 10 to 80% from  $^{51}Cr$  labelled neuroblastoma cells depending on the amoebae to target cell ratio or lysate concentration. Heating the lysate reduces cytopathic activity. Incubation of the lysate for 10 minutes at  $100^\circ C$ , 30 minutes at  $60^\circ C$ , or 1 hour at  $44^\circ C$  substantially reduces the cytopathic activity. The cytopathic effect of the lysate is reduced by incubation at  $37^\circ C$  for 26 hours, however, incubation at 25, 4, or  $-20^\circ C$  for 26 hours has no effect on the lysates activity. The use of the  $^{51}Cr$  release assay and amoebic lysates will be useful in the investigation of Naegleria induced cytopathogenicity. (Supported by Virginia Electric and Power Company and NCI training grant 5 T32 CA 09210-05).

ACCUMULATION AND SUBCELLULAR DISTRIBUTION OF COPPER IN THE RENAL CORTEX OF STZ-DIABETIC RATS. Carol A. Gassman\* and Mark L. Failla, Dept. of Biochem. and Nutr., Va. Polytechnic Inst., Blacksburg, VA 24061. The concentration of copper in kidneys from STZ-diabetic rats increased up to 8.7 times that of controls when animals were fed purified diets (15-20 ppm Cu) ad libitum for 4 weeks. The additional complement of copper was localized entirely in renal cortex. All of the excessive copper present in the cytosol fraction (165,000 x g supernatant) was bound to metallothionein. Separation of organelles from the particulate fraction (165,000 x g pellet) by differential centrifugation revealed that the lysosomal fraction from 3 week STZ-cortex contained 16-fold more copper than that from controls. The presence of significantly increased quantities of copper in lysosomes from diabetic rats has been confirmed by transmission electron microscopy. (Supported by Jeffress Trust Fund and Pratt Animal Nutrition Program).

## PRESSOR DOSE OF ANGIOTENSIN (A-II) vs. PRESSOR DOSE OF A-II + UREA

Jeffery Gipson, Dept. of Chem., Va. Union Univ., Richmond, VA 23220, and  
Karl C. Corley, Dept. of Physiol., Med. Col. of Va., Richmond, VA 23298.

The jugular vein and carotid artery in New Zealand white rabbits (anesthetized by 30 mg/kg Na pentobarbital i.p. or i.v.) were cannulated for infusion of test substances and blood pressure measurements, respectively. Alternate infusion (0.5 ml/min) of D<sub>5</sub>W and increasing doses of A-II in D<sub>5</sub>W until a pressor effect (+20 mm Hg diastolic) was observed ( $125 \pm 12$  ng/kg/min; mean  $\pm$  SE; N = 9). The pressor dose of A-II in 6.6 M urea was then determined to be  $30 \pm 5$  ng/kg/min. The pressor dose was, therefore, significantly reduced by urea ( $t = 11.82$ ;  $df = 8$ ;  $p < 0.001$ ). Adjustment of the pH of the pressor dose of A-II + urea from 7.8 to 7.0 appeared not to affect the potentiation. Infusion of equivalent quantities of A-II and 6.6 M urea (0.2 ml/min) into different veins was done in an attempt to determine if the potentiation depended on a reaction between the two substances before infusion. The potentiation was still observed. Therefore, the enhancement of A-II pressor effects by urea does not appear to be related to the effects of pH or the formation of a new species.

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SYNTHESIS AND BEHAVIORAL COMPARISON OF CONFORMATIONALLY RESTRICTED AMPHETAMINE ANALOGS. A. E. Hauck<sup>\*</sup>, R. Young<sup>\*</sup> and R. A. Glennon<sup>\*</sup>. Department of Pharmaceutical Chemistry, MCV/VCU, Richmond, VA 23298. Rigid analogs of known medicinal agents often demonstrate enhanced activity and/or facilitate our understanding of conformational requirements for efficient receptor binding. In an attempt to determine the active conformation of amphetamine, several conformationally restricted analogs were evaluated. 6-Amino-6,7,8,9-tetrahydro-5H-benzocycloheptene was prepared by the method of Cannon, *et al* and via a thallium trinitrate ring expansion reaction. 7-Amino-6,7,8,9-tetrahydro-5H-benzocycloheptene was synthesized by a modification of the procedure of Anand. These and related analogs, as well as amphetamine and its isomers, were evaluated and compared in a drug discrimination paradigm using rats trained to discriminate (+)-amphetamine from saline. None of the conformationally restricted analogs was as active as (+)-amphetamine. (Supported in part by funding from the A. D. Williams Fund).

EFFECTS OF STIMULATION OF THE MESENCEPHALIC DORSAL RAPHE NUCLEUS ON PLASMA LH AND PROLACTIN IN ESTROGEN-PRIMED AND NON-PRIMED OVARECTOMIZED RATS. Connie S. Kitts<sup>\*</sup> and James H. Johnson. Dept. of Anatomy, MCV/VCU, Richmond, VA 23298.

Stimulation of the dorsal raphe nucleus (DRN) in ovariectomized (OVX) rats increases plasma prolactin (PRL) and decreases LH. Serotonin (5HT) mediates the inhibition of LH release (Arendash, *Endocrinol.* 102:1199). Estradiol benzoate (EB) priming of OVX rats reversed the effect on LH of stimulation of the basal hypothalamus from inhibition to stimulation (*Endocrinol.* 99:659). The present studies were undertaken to learn whether a similar reversal could be observed with stimulation of DRN. Rats OVX at least 4 weeks were implanted with bipolar electrodes in DRN and a cannula in the external jugular vein. Blood samples collected from these unanesthetized rats were assayed by RIA for LH and PRL, and means observed before and during stimulation were compared statistically. Stimulation of DRN decreased LH ( $460-310$  ng/ml;  $p < .006$ ), and increased PRL ( $32-112$  ng/ml;  $p < .002$ ). In rats primed with EB ( $50\mu\text{g/kg}$ , 2 days) stimulation of DRN increased both LH ( $126-173$  ng/ml;  $p < .03$ ) and PRL ( $247-617$  ng/ml;  $p < .05$ ). We conclude that EB alters the mechanisms by which 5HT neurons in DRN influence the activity of LH-RH producing neurons in the basal hypothalamus. (Supported by NIH Grant HD12165).

THE INFLUENCE OF ETHANOL AND CORTICOSTERONE ON REPRODUCTIVE FUNCTION IN THE ADULT FEMALE RAT. R.J. Krieg Jr., K.A. McGregor\*, and L.N. Murad\*. Dept. of Anatomy, MCV-VCU, Richmond, VA. 23298.

These studies were designed to investigate the effects of ethanol (EtOH) and corticosterone (CS) on estrous cyclicity, on the proestrous surges of luteinizing hormone (LH) and prolactin (PRL), and on PRL receptors in the liver. Adult female Sprague-Dawley rats received drinking solutions consisting of tap water, or 4% EtOH in tap water, or one of two doses of CS (40ug/ml, or 400 ug/ml) in 4% EtOH, for a period of 6 weeks. Although comparable doses of CS had been shown to delay the onset of puberty in young animals, neither dose of CS caused a disruption of estrous cyclicity in adult animals. EtOH caused no change in cyclicity. The preovulatory surge of LH was not affected by EtOH or CS, and ovulation was readily observed in all four groups. The proestrous surge of PRL was not affected by any of the treatments. There was a significant affect of EtOH and CS on liver PRL receptors, however. EtOH and low-dose CS in 4% EtOH decreased PRL receptors by 25.3% and 20.0%, respectively; and high-dose CS decreased PRL receptors by 43.8%. These results may be significant with reference to the relatively common occurrence of gynecomastia in adult human alcoholics. (Supported by NSF Grant #PCM79-22155).

FIBRINOGEN WHITE MARSH-A NEW HUMAN FIBRINOGEN VARIANT WITH A- $\alpha$  CHAIN DEFECT.

J. G. Magnant, R. M. Vennart, H. J. Evans, J. A. Koehn, G. D. Qureshi, Dept. of Med., Med. Col. of Va., Richmond, Va. 23298. Congenital dysfibrinogenemia is a rare disorder which may lead to a compromised hemostatic function. A 19 year old female bled excessively following childbirth. Her past and family history for bleeding tendencies or thrombosis was negative. Her prothrombin time was 14 sec. (control 12), activated partial thromboplastin time 34 sec. (control 25) thrombin time 44 sec. (control 19), reptilase time 34 sec. (control 25). Her fibrinogen was 79 mg/dl by a clotting time method and 384 mg/dl by immunological method. Similar abnormalities were found in her mother and three brothers. The kinetics of cleavage of her purified fibrinogen with thrombin, reptilase and southern copperhead snake venom demonstrated markedly impaired fibrinopeptide A release and normal release of fibrinopeptide B. The rate of fibrin monomer polymerization was normal. The amino acid sequence studies of A- $\alpha$  chain of her purified fibrinogen demonstrated Arg<sup>16</sup>His substitution which appeared to be responsible for the abnormal behavior of her fibrinogen. This fibrinogen variant is designated as, "Fibrinogen White Marsh" after the patient's place of origin in Virginia.

EFFECTS OF PARTICULATES ON THE UPTAKE AND METABOLISM OF BENZO(A)PYRENE. Walter E. Manger\*, David R. Bevan, Dept. of Biochem., VA Polytechnic Inst., Blacksburg, VA 24061. The carcinogenic potency of benzo(a)pyrene (BP), a polynuclear aromatic hydrocarbon, is known to increase when instilled or inhaled with particulate matter. Mechanisms for this phenomenon are not known. In the present study, the effect of two particles, one fibrous (Canadian chrysotile) and the other non-fibrous (hematite), on BP metabolism as a function of uptake rate into liver microsomes isolated from 3-methylcholanthrene-treated animals was observed. In addition, the effects of the particle on enzymes involved in BP metabolism, i.e., cytochrome P-450, and epoxide hydrase, have been studied. The metabolism of BP is increased when it is taken into the microsomes from the particle-adsorbed state as compared to the microcrystalline state as would be expected based on the total amount of BP available to the microsomes, even though the particles inhibit the activities of the two enzymes mentioned above.

CHLORDECON (CD) POTENTIATION OF  $\text{CCl}_4$  HEPATOTOXICITY IN RATS AND GERBILS. E.A. McGrath\* and R.E. Ebel, Dept. Biochem., Virginia Tech, Blacksburg, VA 24061 CD and phenobarbital (PB), but not mirex, treatment have been shown to potentiate the hepatotoxicity of  $\text{CCl}_4$  in rats. Each of these compounds induces cytochrome P-450, the enzyme responsible for the production of toxic metabolites of  $\text{CCl}_4$ .  $\text{CCl}_4$  hepatotoxicity is monitored by increases in SGPT and SGOT, decreases in cytochrome P-450, histopathological changes, and a dramatic loss of a 50 kdal protein (SDS-PAGE). These changes are a function of  $\text{CCl}_4$  dose. The gerbil was chosen as a model for human CD exposure since the metabolism of CD is similar in these species. As with the rat, CD, PB and mirex are inducers of cytochrome P-450. However, the uninduced gerbil is significantly more sensitive to  $\text{CCl}_4$  than the rat. Treatment of male gerbils with CD, PB or mirex has a protective effect compared to control animals with respect to  $\text{CCl}_4$  toxicity. Of the three, CD provides the least protection while the effect with PB or mirex is comparable.

STUDIES ON SOME POTENTIAL SEROTONERGIC AGENTS. J. D. McKenney\*, J. M. Jacyno\*, and R. A. Glennon\*, Department of Pharmaceutical Chemistry, Medical College of Virginia, Virginia Commonwealth University, Richmond, Virginia 23298. A novel series of N,N-dimethylisotryptamine (isoDMT) derivatives, i.e. derivatives of 1-(2-dimethylaminoethyl)indole, was prepared and found to be isosteric with their corresponding N,N-dimethyltryptamine (DMT) counterparts with respect to serotonin receptor (rat fundus) affinity. Whereas the isoDMT derivatives possessed a greater affinity than did their corresponding DMT derivatives, they were relatively ineffective in displacing [ $^3\text{H}$ ]-5-HT binding from rat brain (cortex) homogenates. In a drug discrimination paradigm, using rats as subjects, 6-OMe isoDMT produced effects similar to those of 5-OMe DMT. (Supported in part by USPHS grant DA-01642 and research funds from the A. D. Williams Fund.)

ON SAGER'S RECIPROCITY IN REACTION-DIFFUSION SYSTEMS: A NETWORK THERMODYNAMIC APPROACH. Donald C. Mikulecky, Dept. of Physiol. & Biophys., MCV/VCU.

The King-Altman diagrammatic method for deriving kinetic expressions for enzymatic reactions has been extended to reaction-diffusion systems (especially active transport) by T. Hill (*Free Energy in Biology*, Academic Press, NY, 1977). Peusner has developed an alternative, but complementary network thermodynamic representation (*J. Chem. Phys.* 77: 5500-5507, 1982), which demonstrates that new flow-force coordinates are necessary to exhibit Onsager's reciprocity in these systems. The new coordinates are based on finding a potential which is compatible with the metric used to "measure" the irreversible dissipation in the system. In this work, Mason's unistor is introduced as a means to represent nonreciprocal systems and it is shown that the principle of detailed balance insures that these nonlinear systems are reciprocal at equilibrium and obey Onsager's reciprocity at that point.

PROTEOLYTIC ACTIVITY OF GUINEA PIG SPERM. Noel O. Owers, Department of Anatomy, Virginia Commonwealth University, Richmond, Va. 23298.

The aqueous extracts of epididymal sperm digest a fixed gelatin membrane (Owers and Blandau, Chapter 11, in "Biology of the Blastocyst, Univ of Chicago Press 1971), forming circles whose area is proportional to concentration. Individual sperm incubated on the membrane also digest it forming areas of lysis associated with the acrosome. It has not been known whether the proteases in the acrosome undergo changes during passage of sperm through the uterus, vagina and oviduct, or not. Female guineapigs were mated overnight and the following day the vagina, uterus and oviduct were excised and washed with veronal acetate buffer pH 4.5, or 7 and/or 8 containing 0.9% NaCl. The washings contained between 5 and 100 sperm in the uterus and tubes, more in the vagina. The sperm were smeared on a gelatin membrane and incubated overnight with buffer at pH 4.5 and 8.4. The areas of digestion were measured using a microscope, and a statistical analysis done for the sperm obtained from each organ. The results were compared with a similar experiment using epididymal sperm. The results indicate that the sperm proteases probably remain unchanged in the female genital tract up to the time of fertilization.



HISTOLOGICAL EXAMINATION OF THE INFLAMMATORY RESPONSE TO CORNEAL IMPLANTS OF PHAGOCYTIC LEUKOCYTES. James W. Moore, III and Milton M. Sholley. Dept. of Anatomy, Virginia Commonwealth Univ., Richmond, VA 23298. Inflammatory peritoneal macrophages (MØ) injected into the stroma of guinea pig corneas have been shown to induce vascularization of the normally avascular cornea. Neutrophils have been implicated as inducers of corneal vascularization in rats, although conflicting results have been obtained in other animals. Due to this controversy and the reported absence of infiltrating neutrophils in response to MØ, we investigated the potential of purified preparations of peptone elicited peritoneal MØ or neutrophils to induce vascularization in rabbit corneas. Our results show that autologous implants of elicited MØ induce vascular responses, whereas similar implants of neutrophils do not induce vascularization. Histological examination at 4 to 24 hours revealed a significant infiltration of neutrophils from the limbal vasculature toward and reaching the MØ or neutrophil implant. Infiltration was negligible at 48 hours and later times. These results show that autologous inflammatory MØ induce neovascular responses in the rabbit cornea and that there is early infiltration of the cornea by neutrophils. However, neutrophils cannot be the inducing factor in vascularization, since vascular responses occurred only to MØ implants. (Aided by NCI grant CA-26316)

RECONSTITUTION OF THE IRON SUPEROXIDE DISMUTASE FROM BACTEROIDES THETA IOTA O-MICRON. Charles D. Pennington\* and Eugene M. Gregory, Department of Biochem. and Nutr., V.P.I., Blacksburg, VA 24061. Superoxide dismutase (SOD) from *Bacteroides thetaiotaomicron* has been purified 220 fold to apparent homogeneity as determined by HPLC and gel electrophoretic techniques. The specific activity of the isolated SOD is 2200 U/mg. The enzyme has a molecular weight of 40,000 and is composed of two equal sized subunits joined by noncovalent interactions. The enzyme contains 2 gram atoms Fe and 1 gram atom Zn per mol. of dimer. Enzymatic activity is lost upon treatment with 5 M guanidinium Cl and 20 mM 8-hydroxyquinoline. The denatured apoenzyme regains activity after dialysis against either 1 mM ferrous ammonium sulfate or .1 mM manganous chloride in tris buffer. Ten µM zinc sulfate will inhibit Fe-reconstitution by 78% and Mn-reconstitution by 64%. The Fe-reconstituted and native enzyme have an apparent pH optimum of 6 whereas the apparent pH optimum of the Mn-reconstituted enzyme is 7.8. The native and Fe-reconstituted enzymes are inhibited 50% by .27 mM and .31 mM azide respectively. The Mn-reconstituted enzyme is inhibited 26% by 10 mM azide. (Supported in part by NIH Grant AI15250-04)

SIALYLOLIGOSACCHARIDES OF HUMAN MILK: ISOLATION AND IDENTIFICATION BY ANTI-SIALYL OLIGOSACCHARIDE ANTIBODIES. Pedro A. Prieto\* and David F. Smith, Dept. of Biochemistry, VA Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Rabbit antiserum against the human milk oligosaccharide LSTb (Galβ1-3[NeuAcα2-6]GlcNacβ1-3Galβ1-4Glc) is used to isolate a new, structurally related oligosaccharide. [<sup>3</sup>H] Sialyloligosaccharides from milk of different Lewis blood group donors are separated by paper chromatography. The sialyloligosaccharides are assayed for LSTb and related structures using anti-LSTb serum in a direct-binding radioimmunoassay. An oligosaccharide which moves slower than LSTb during paper chromatography is isolated. Based on its specific binding to anti-serum, its absence from Le<sup>a</sup> milk and its co-chromatography with lacto-N-fucopentaose I (Fucα1-2Galβ1-3GlcNacβ1-3Galβ1-4Glc) after neuraminidase digestion, the proposed structure is: Fucα1-2Galβ1-3[NeuAcα2-6]GlcNacβ1-3Galβ1-4Glc.

STUDIES ON THE MECHANISM OF ACTION OF SOUTH AMERICAN  $\beta$ -CARBOLINE HALLUCINOGENS. R. Mark Slusher\* and Richard A. Glennon\*, Department of Pharmaceutical Chemistry, MCV/VCU, Richmond, Virginia 23298. Harmala alkaloids, derivatives of  $\beta$ -carbolines, appear to be the active constituents of a hallucinogenic decoction variously known as caapi or ayahuasca. The  $\beta$ -carboline structure contains a rigid indolealkylamine (IAA) backbone. Various other IAAs are hallucinogenic in man and have been previously shown to interact with serotonin (5-HT) receptors *in vitro*; many of these IAAs are also active in tests of discriminative control of behavior in rats. We found that certain  $\beta$ -carbolines are also active in this same paradigm. In order to gain further insight as to the nature of substituent effects, several novel derivatives were synthesized and evaluated using the drug discrimination paradigm. (Supported by USPHS grant DA-01642).

DIETARY SUPPLEMENTATION WITH VITAMIN C DELAYS ONSET OF MUSCLE FATIGUE. J. Richardson, S. Smith, and R. Allen\*, Dept. of Biol., Old Dominion University, Norfolk, Va. 23508. Prolonged vitamin C dietary supplementation increased contraction time in isolated striated muscle but had no effect on the strength of the contraction. A total of thirty measurements were collected, fifteen from control and fifteen from experimental animals. The experimental animals were force fed 30 mg of vitamin C per day. Following the dosing period, the animals were anesthetized and the gastrocnemius muscle was exposed. The leg and foot were immobilized by clamping and the Achilles tendon was attached to a "B" strength myograph which in turn registered muscle contractions on a physiograph. The muscle was stimulated with an electrical probe using eight volts of 20 cycles per second until the muscle fatigued.

THE EFFECT OF GLUCOSE DOSING ON MUSCLE FATIGUE. J. Richardson, S. Smith, and R. Allen\*, Dept. of Biol., Old Dominion University, Norfolk, Va. 23508. After dosing with glucose, time to fatigue was measured in the gastrocnemius muscle in eleven experimental animals. Results indicate that contraction time was 23% longer for the dosed animals than for control animals. Ingestion of glucose thirty minutes prior to exertion increases stamina by prolonging muscle contraction. Stamina was determined by anesthetizing the animals and exposing the gastrocnemius muscle. The Achilles tendon was attached to a spring loaded myograph of controlled tension. Muscle contraction was induced by an electrical probe using eight volts at 20 cycles per second. Time to fatigue was measured twice on the same muscle, but only the second contraction was used for data analysis. The muscle was allowed a 40 second recovery period between stimulations.

REGULATION OF MACROPHAGE (M $\phi$ ) Ia ANTIGEN EXPRESSION BY T CELL PRODUCTS. Lawrence B. Schook, Dept. of Microbiology and Immunology, Medical College of Virginia, VCU, Richmond, VA 23298. M $\phi$  were obtained from mouse bone marrow grown in the presence of colony stimulating factor (CSF). These M $\phi$  were phenotypically characterized for Ia antigen expression, ectoenzyme activities and effector functions during their *in vitro* differentiation. The kinetics of Ia antigen expression and tumoricidal activity of these M $\phi$  were disparate. Ia antigen expression was CSF dependent and began at 3d of culture, was maximal after 5-7d, and then declined. M $\phi$  tumoricidal activity appeared after 7d, when the spontaneous expression of Ia had declined. Treatment of M $\phi$  at 7d with lymphokines (LK) was able to maintain Ia antigen expression with no increase in tumor cell killing. Treatment with LK only increased tumor cell killing of BMDM obtained early during differentiation. Moreover, the more differentiated BMDM were less responsive to LK modulation of phenotypic characteristics indicating more stable phenotypes. (Supported by a grant from the American Cancer Society (IN-105G)).

## SYNTHESIS, ANALYSIS AND BEHAVIORAL EFFECTS OF 2,3-METHYLENEDIOXYAMPHETAMINE.

W. H. Soine, R. Young\* and R. A. Glennon, Dept. of Pharm. Chem., MCV/VCU, Richmond, VA; R. E. Shark\* and D. T. Agee\*, Drug Examination Section, Bureau of Forensic Science, Consolidated Lab. of Virginia, Richmond, VA 23219. Forensic and pharmacological differentiation of the methylenedioxyamphetamines (MDA) required the synthesis of the previously unreported 2,3-methylenedioxyamphetamine which was converted to the nitropropene intermediate and then reduced with  $\text{LiAlH}_4$ . For forensic purposes the isomers could be differentiated using the sulfuric acid color test, gas chromatography, mass spectrometry and  $^{13}\text{C}$  nuclear magnetic resonance. When I was tested in rats trained to discriminate (+)-3,4-MDA from saline in a two-lever drug discrimination task, generalization was found to occur, but I was 1/5 as active. Stimulus generalization did not occur with I using rats trained to (+)-2,5-dimethoxy-4-methylphenylisopropylamine (DOM) or (+)-amphetamine. (Supported in part by NIDA grant DA-01642).

## INFLUENCE OF SEX, STRAIN AND SPECIES ON ALTERED TRACE METAL METABOLISM IN THE STZ-DIABETIC RODENT. Susan A. Spittle\* and Mark L. Failla, Dept. of Biochem. and Nutr., VA Polytechnic Institute and State Univ., Blacksburg, VA 24061.

Previous studies have demonstrated marked alterations in trace metal metabolism in male SD rats following chemical induction of diabetes. To determine whether such changes represented a general response to the insulin-deficient condition the levels of Zn, Cu and Mn in liver (L), kidney (K), and intestine of normal and streptozotocin (STZ)-diabetic male rats of the Sprague-Dawley, Wistar and Long-Evans strains, female Sprague-Dawley rats and male mice were measured. Significantly increased concentrations of Zn, Cu and Mn in L and Zn and Cu in K were found in STZ-diabetic rats, regardless of sex and strain. In contrast, Zn and Cu contents in L and K of control and diabetic mice were similar, but Mn levels were significantly elevated in both organs of the diabetic mouse. Higher amounts of Zn and Cu were bound to metallothionein in L and K of diabetic rats. (Supported by Pratt Nutrition Program and USDA).

## CELL MEDIATED ANTIGEN TRANSPORT TO LYMPH NODE GERMINAL CENTERS. Szakal, A.K.,

Schnizlein\*, C., and Tew, J.G. Dept. of Anat. and Microbiol., Med. Coll. of Virginia/VCU, Richmond, Virginia. 23298. Long term antigen (Ag) retention in lymph node and spleen germinal centers (GC) by follicular dendritic cells (FDC) is well known. Evidence for the role of this phenomenon in the maintenance of long term immunity is mounting. The mechanism by which Ag arrives in lymph node GCs is unknown. Hypotheses from passive drainage to active transport by lymphocytes or macrophages have been proposed. The method of entry of Ag into GCs was systematically studied by light and electron microscopy in C<sub>3</sub>H mouse popliteal lymph nodes 1,5,15,30 minutes and 1,5, and 24 hours after foot pad injection of the Ag, HRP. Light microscopy showed an apparent migration of the peroxidase positive Ag on the afferent side of the lymph node from the subcapsular sinus (SS) at specific areas to regions of GCs. This occurred only in passively immunized controls indicating antibody dependence. Antigen migration into the cortex was already in progress at 1 min and formed continuous trails between the SS and GCs between 1 min and 5 hrs. By 24 hrs the trails disappeared and HRP was localized in GCs. Electron microscopy showed that HRP was transported to GCs on the surface of a group of cells of possible monocyte origin. Morphology suggested that these cells may be precursors to FDCs.

SYNTHESIS OF MESOIONIC THIADIAZOLOPYRIMIDINE NUCLEOSIDES AS POTENTIAL ANTINEOPLASTIC AGENTS. S. M. Tejani\* and R. A. Glennon\*, Department of Pharmaceutical Chemistry, MCV/VCU, Richmond, VA 23298. 2-Amino-1,3,4-thiadiazole (2-ATD) possesses activity as an antineoplastic agent. Although its exact mechanism of action is not yet fully understood, evidence suggests that it may undergo an exchange reaction with NAD to form a 2-ATD mononucleotide. A crude nucleotide metabolite (of unknown structure) of 2-ATD was isolated and demonstrated to be an inhibitor of IMP dehydrogenase obtained from leukemia L1210 cells. We synthesized 2-(D-ribofuranosylamino)1,3,4-thiadiazole; however it was found to be unstable. Mesoionic thiadiazolopyrimidine analogs of the above compound were prepared as potential prodrugs to modify the pharmacodynamic properties of the parent nucleoside and in an attempt to enhance stability. These potential prodrugs might be predicted to slowly liberate the parent nucleoside *in vivo*. These compounds are currently being assayed for toxicity to L1210 and HEP-2 cells. (Aided by American Cancer Society Institutional Grant IN-105H).

QUANTITATIVE IMMUNOHISTOCHEMISTRY OF PROLACTIN BINDING SITES IN VENTRAL PROSTATES OF RATS TREATED WITH INDOMETHACIN. R.S. Vick\*, J.R. Dave\*, R.J. Witorsch\*, Dept. of Physiology, Med. Col. of VA., Richmond, VA 23298. This study determined whether indomethacin (Indo) treatment had any effect on the immunohistology of prolactin (PRL) binding of rat ventral prostate (VP). Rats were injected with one of two doses of Indo for 0, 48, or 72h. VP sections were immunostained for PRL binding sites by the immunoperoxidase method. Immunostaining was quantitated by two methods: the proportion of cells immunostained as measured by an image analyzer and the intensity of immunostaining per cell as measured by a microscope densitometer. Linear regression between the two parameters showed a positive correlation at  $r = 0.75$ . The product of the two parameters was used to estimate total PRL binding in VP. We found a significant increase in PRL binding with the low dose of Indo at 48h and significant decreases in PRL binding with the low dose at 72h and high dose at 48h. These immunohistochemical observations did not agree with our radioreceptor data which showed that Indo produced a time and dose dependent decrease in PRL binding. These contrasting observations will be discussed. (NIH grant CA 23653).

Characterization of Active and Inactive Forms of Rat Hepatic HMG-CoA Reductase. Terence R. Whitehead\*, Z. Reno Vlahcevic, and Phillip B. Hylemon, Depts. of Microbiology and Immunology, and Medicine, Med. Coll. Va., Va. Common. Univ., Richmond, VA 23298. HMG-CoA reductase, the rate-limiting enzyme in cholesterol biosynthesis, was purified 4,500-fold with a specific activity of 8,930 nmoles/min/mg, using agarose-HMG-CoA affinity chromatography. SDS-PAGE of the purified enzyme demonstrated one protein band. Additional protein isolated from the affinity column with 0.5 M KCl demonstrated no HMG-CoA reductase activity, yet co-migrated with the active enzyme on SDS-PAGE. This protein was determined to be an inactive form of HMG-CoA reductase by tryptic peptide mapping, reaction with anti-HMG-CoA reductase antibody, and molecular sieving HPLC. Microsomal HMG-CoA reductase activity was found to be sensitive to the sulfhydryl inhibitors PHMB and  $\text{HgCl}_2$ , but not NEM. Both NADPH (4 mM) and HMG-CoA (176  $\mu\text{M}$ ) were able to protect the enzyme against inhibition, indicating sulfhydryl groups are present in the active site of HMG-CoA reductase.

MICROCOMPUTERS FOR PERSONAL INFORMATION STORAGE AND RETRIEVAL, Abund Ottokar Wist, Dept. of Physiology and Biophys., MCV/VCU, Richmond, VA 23298.

The rapid increase in knowledge and accompanying increase in the number of scientific papers, books, and other sources of information makes it increasingly difficult on the part of individual investigators to keep abreast of the literature relating to their fields. Computer assisted literature searches are too comprehensive and often do not provide the desired information.

Investigators on the frontiers of research seem to get the least benefit from such searches as a short review of literature search techniques shows. People with the least experience learn to use the library facilities most often. Therefore research workers with high experience set up their own literature search system which even though it is mostly manual fits better to their needs.

Recently new technology such as mini- and microcomputers have been used together with new search techniques to adapt the capabilities of a modern library more specifically to the needs of academic and medical research workers. Several such systems around the country will be described, together with a system we are developing here at the Medical College of Virginia/VCU.

## Microbiology Section

BOVINE PARVOVIRUS ASSOCIATION WITH THE NUCLEAR MATRIX OF INFECTED CELLS.

Laura L. Briggs\*, Robert C. Bates, and Ernest R. Stout. Dept. of Biol., Virginia Polytechnic Institute and State Univ., Blacksburg, Va. 24061.

The nuclear matrix is a proteinaceous structure to which supercoiled loops of DNA are attached. The object of this research was to determine the nature of the association of Bovine Parvovirus (BPV) DNA and viral specific proteins with the nuclear matrix of infected cells. Matrices were prepared from virus-infected cells using two different procedures both utilizing non-ionic detergents and high salt conditions. Analysis of the DNA isolated from the matrices prepared from SV40-transformed bovine fetal lung cells infected with BPV show viral DNA to be associated with the nuclear matrix. Treatment of these preparations with increasing DNase concentrations ranging from 0 to 100  $\mu\text{g/ml}$  does not decrease the amount of single-stranded BPV DNA associated with the matrix. Yet the amount of double-stranded BPV DNA does decrease with increasing DNase concentrations. SDS-polyacrylamide gel electrophoresis of matrix proteins demonstrates the presence of one viral capsid protein and one low-molecular weight, viral-coded nonstructural protein, NP1. The association of viral DNA and proteins with the nuclear matrix implicates a role for the matrix in the viral replication process.

THE POLAR AND LATERAL FLAGELLA OF AZOSPIRILLUM BRASILENSE ARE ANTIGENICALLY

DISTINCT. Patrick G. Hall & Noel R. Krieg, Dept. of Biol., Va. Polytech. Inst. & State Univ., Blacksburg, VA. 24061. An indirect immunoperoxidase stain was used to demonstrate by electron microscopy that an antigenic difference exists between the polar flagellum and the lateral flagella of Azospirillum brasilense ATCC 29145. No evidence could be obtained that the polar flagellum was ensheathed as it is in Vibrio spp. The diameter and wavelength of the two types of flagella are reported.

DIMINISHED INTERLEUKIN 3 (IL-3) ACTIVITY IN TUMOR-BEARING HOSTS (TBH). A.F. Lentine, C.J. Burger, C.J. Denbow\*, and K.D. Elgert. Biology Dept., Microbiology Section, Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

IL-3 is produced during the generation of specific cytotoxic T lymphocytes (CTL). A kinetic study of IL-3 production during tumor growth revealed a decreased ability of TBH mouse splenocytes to produce IL-3. Removal of suppressor T cells did not restore IL-3 production in TBH splenocytes. Absorption studies suggested that fresh cells have more accessible IL-3 receptors than Con A-induced blast cells. Blastogenic assessment showed purified IL-3 was mitogenic for normal but not TBH splenocytes. IL-3 augmented the *in vitro* response of normal splenocytes to Con A and PHA but suppressed the TBH splenocyte response. Purified IL-3 inoculated into normal and TBH resulted in a suppression of TBH splenocyte blastogenesis. The further decrease in TBH splenocyte activity with exogenous IL-3 may be caused by tumor-induced feedback mechanisms that suppress cellular differentiation required for specific CTL generation. (Supported by NIH Grant CA25943 and a Whitehall Foundation Grant.)

DNA/DNA HOMOLOGY STUDIES ON THE GENUS GLUCONOBACTER. Bruce Micales, J.L. Johnson and G.W. Claus, Virginia Tech, Blacksburg, Va. 24061. Since the present taxonomy of the genus Gluconobacter is based largely on phenotypic data, we investigated them in terms of nucleotide sequence similarity. Using a S1 nuclease procedure, we determined DNA homologies from 39 strains of Gluconobacter, together with 30 strains of Acetobacter, Frateruia, and Pseudomonas. Three DNA homology groups were obtained with organisms generally fitting the description of the genus Gluconobacter. The average intergroup relatedness among the three homology groups was 20%. Type strains of the five subspecies of G. oxydans all belonged to homology group I, with intra- and intersubspecies homologies ranging from 62-100%. Homology group II was defined by reference strain IFO 3264 and showed an intragroup homology of 44-87%. Homology group III was defined by reference strain IFO 3276 and showed an intragroup homology of 68-99%. Our data suggests that the genus Gluconobacter is composed of at least three species and the current recognized subspecies are not justified.

ASCITES FORMATION IN CHICKENS TRIGGERED BY RES OVERLOAD. Robert L. Taylor, Jr.\*, Dept. of Pathology, Medical Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298, Imre Olah\* and Bruce Glick\*, Dept. of Poultry Science, Miss. State Univ., Miss. State, Miss 39762. Rapid ascites formation was observed in the hepatoperitoneal sac 4 to 5 hours after IV injection of large amounts of carbon. The amount of ascitic fluid varied from 0.5 to 12 ml/chicken. The protein content of ascitic fluid was identical to that of serum. Total antibody titers to sheep red blood cells in ascitic fluid and serum were also similar. Specific IgM antibody in ascitic fluid was significantly lower than that in serum while the former showed more IgG antibody. The cellularity of ascitic fluid was poor consisting of mononuclear cells which were mainly macrophages with or without phagosomes. A few small lymphocytes and large numbers of thrombocytes were also present. In those animals with large amounts of ascitic fluid, caecal pouch contents were solid and relatively dry. These data suggest that a mechanism may exist which regulates water balance between the liver and the caecal pouch.

MEMBRANE PROTEINS OF A METHANE-OXIDIZING BACTERIUM. Terry L. Weaver, Dept. of Biol., Liberty Baptist College, Lynchburg, Va. 24506. The methane oxidizing bacteria possess internal membrane vesicles regularly stacked in particular arrangements in the cytoplasm. The bacterium used in this study, Methylosinus trichosporium, was grown in liquid under a methane/air (1/1) mixture, and after concentration the cells were disrupted using a Braun homogenizer. Internal membranes were isolated via differential centrifugation. Membrane protein samples were hydrolyzed in HCl, and the polar amino acids were separated from the apolar by TLC. It was found that the amino acid composition of the membrane proteins was relatively enriched in apolar amino acids at over 71%. Electrophoresis revealed five major membrane proteins with molecular weights of 47,000, 80,000, 125,000, 160,000, and 180,000. The membrane proteins were also analyzed spectrophotometrically for cytochromes via oxidized vs. reduced spectra and for the presence of enzymes using standard assay procedures. Cytochromes C and A, a cytochrome C reductase, and ATPase activities were all associated with the membranes. Thus the internal membranes in these bacteria appear to function primarily in electron transport and oxidative phosphorylation.

THE EFFECT OF FRUCTOSE ON PROTEIN SYNTHESIS AND HETEROCYST FORMATION IN SEVERAL SPECIES OF CYANOBACTERIA. J. Ernest Wilson, Judith W. Scott, and Lisa C. Reekes, Dept. of Life Sciences, Va. State Univ., Petersburg, Va 23803. 5.0 mM fructose increases growth and protein synthesis in several species of cyanobacteria with heterocysts. Species which do not form heterocysts do not respond to fructose. When species that form heterocysts are grown in the presence of nitrate and ammonia which inhibit heterocyst formation, fructose does not increase growth or protein synthesis. If heterocysts are initially present in filaments treated with fructose and nitrate, a large initial increase in growth is found which disappears with time. Fructose increases heterocyst formation. It is suggested that these results would be obtained if fructose was the sugar which is normally transferred from vegetative cells to heterocysts.

SENSITIVITY OF SEVERAL CELL LINES FOR INTERFERONS WHEN CHALLENGED WITH VSV AND EMC VIRUS. S. Yousefi\*, C. W. Gouldin\* and M. R. Escobar. Medical College of Virginia, Richmond, VA 23298. The clinical significance of quantitating IFNs in various human disorders has been confirmed. Among several criteria for choosing an IFN assay are simplicity, rapidity, cost-effectiveness, reproducibility, and sensitivity as well as its potential for automation. Diploid fibroblasts, despite their sensitivity, have inherent limitations. This problem led us to evaluate monolayers of WISH, HEp-2, Vero, A549 and WI-26VA4 cell lines challenged with vesicular stomatitis virus (VSV) and encephalomyocarditis virus (EMCV) using the conventional dye uptake assay for HuIFN- $\alpha$  and HuIFN- $\gamma$ . A549 and WI-26VA4 did not meet these criteria. Vero cells challenged with EMCV were found to be suitable for HuIFN- $\alpha$  alone yielding high reproducibility, provided that sensitivity is not crucial. HEp-2 cells, readily available in the diagnostic lab., challenged with VSV are very acceptable for both IFNs, particularly IFN- $\gamma$ . WISH cells with EMCV, instead of VSV, were found to be the most sensitive for both IFNs; however, these cells are not as readily available. A modification of the assay described above using WISH cells challenged with EMCV is more rapid without significant loss of sensitivity. It also lends itself to automation when screening large numbers of samples for HuIFN- $\alpha$  and HuIFN- $\gamma$ .

## Psychology Section

PSYCHODIAGNOSTICS OF VOICE ANALYSIS: EXPERIMENTAL VALIDITY OF THE VOICE "STRESS-DISSECTION TEST." John C. Bartone, Department of Research, American Health Research Institute, Ltd., Annandale, Va. 22003. Voice analysis, per se, or attempts to "analyze" the voice by any form of stress evaluation, is a new field, inviting to all professions, and highly sensitive to differential errors unknown to all. Voice analysis is particularly applied in "lie detection" wherein proneness to errors is manifold. One ingenious experiment, the "Stress-Dissection Test," subject to universal application and adoption must be declared scientifically unsound, psychologically invalid and logically inapplicable.

The parameters of the Stress-Dissection Test do not exist, have not been published and may contribute further confusion if applied consistently in the Lie Detection commercial arena.

The Stress-Dissection Test is particularly dangerous in that clients, prisoners or patients may be given status that is against societal requirements. The high stress conditions under which this test operates is hazardous to clients, experimenters and outcome.

THE EFFECT OF BILATERAL LESIONS OF THE NUCLEUS BASALIS OF MEYNERT ON SPATIAL BEHAVIOR. Paul Chapman\*, Dept. of Psychology, Washington & Lee Univ., Lexington, VA. 24450. (Sponsor: L. E. Jarrard)

The effects of bilateral ibotenic acid lesions of the nucleus basalis of Meynert were tested in rats. This area has been shown to have important connections to neocortex as well as several limbic system structures. Two experiments were performed to examine the effects of damaging the nucleus on spatial memory. Since this nucleus has been implicated in Alzheimer's disease in humans, tasks were designed to test the animals working ("recent") memory, both on postoperative acquisition and retention of preoperative learning. The first of these involved memory in a radial maze on cued and non-cued tasks, and the second was a single alternation task. No reliable differences were found on either type of learning. The results of these experiments suggest that the inputs from the nucleus basalis, particularly to the limbic system, have little or no importance in spatial learning or retention.

RESPONSE BIAS IN A FIXED INTERVAL SCHEDULE. R. Feguson, P. Martin, and M. Griffin, Dept. of Psychology, Va. State Univ., Petersburg, Va. 23803. Responding under Fixed Interval (FI) schedules typically begins after only about 50 percent of the interval has elapsed. This has been attributed to a schedule bias: late responses are punished by delaying reinforcement while early responses are relatively effortless. The purpose of this research was to test this view by making early responses more "expensive". Twelve Holtzman male rats were initially trained on an FI60 sec schedule to which was then added a loud buzzer for .5 sec immediately following each response. Statistical analyses indicated no significant differences between the response functions under baseline and buzzer conditions. Subsequent research has demonstrated that the buzzer is an aversive stimulus and that the absence of a buzzer effect in the FI data can not be attributed to stimulation deafness. These data thus call into question the adequacy of the schedule bias account of FI responding. This work was supported by NIH/MBBS Grant No. RR 08090-11.



BEHAVIORAL CONTRAST AND TEMPORAL DISCRIMINATION. R. Ferguson, P. Martin, and S. Lambert, Dept. of Psychology, Va. State Univ., Petersburg, Va. 23803. Responding under fixed interval (FI) schedules of reinforcement has been characterized as representing a temporal discrimination process in which different temporal points in the interval serve as discriminative stimuli. The purpose of this experiment was to test this view by attempting to demonstrate behavioral contrast along a strictly temporal dimension. Twelve male Holtzman rats were trained on a discrete trial mixed FI30-FI60 sec schedule and then shifted to a discrete trial mixed EXT-FI60 schedule in which the 30 sec trials terminated with lever retraction but no reinforcement. The data from the second phase of the study showed clear evidence of contrast: responding during sec 20-30 of each trial decreased across the 15 test days while responding during sec 50-60 increased. These data thus strongly suggest that time serves as a discriminative stimulus in temporal schedules of reinforcement. This work was supported by NIH/MBS Grant No. RR-08090-11.

THE EFFECTS OF UNILATERAL AND BILATERAL ENTORHINAL LESIONS ON SPATIAL MEMORY IN THE RAT. H. E. Gill\*, G. K. Mauser\*, and E. D. Vaughan\*, Dept. of Psychology, Washington & Lee Univ., Lexington, VA. 24450. (Sponsor: L. E. Jarrard)

The effects of unilateral and bilateral entorhinal cortex (EC) lesions on retention of a complex spatial task were studied. Rats were initially trained in the Morris water task. This task consists of a circular pool filled with opaque water where the subjects have to find safety on a platform located just below the water. After learning to locate the hidden platform, unilateral, bilateral, and sham EC lesions were performed. Three days following the operations testing on the task was resumed. Unilateral lesioned rats were slightly impaired but the results were not statistically different from the operated controls. Bilateral lesioned rats initially showed a large deficit in performance, but performance gradually improved over trials. The results will be discussed as they relate to synaptogenesis and recovery of function.

THE USE OF THE AWARENESS SESSION IN MOTIVATING SEAT-BELT USAGE: THE APPLICATION OF SOCIAL PSYCHOLOGICAL PRINCIPLES IN AN INDUSTRIAL SETTING. Heidi Ann Hahn\* & E. Scott Geller, Dept. of Psych., Va. Polytechnic Inst. & State Univ., Blacksburg, Va., 24060. Research has shown that seat-belt wearing among white-collar workers can be motivated through the use of incentives. Incentive strategies have not, however, been effective among blue-collar workers. Using the principles of social psychology, an "awareness session", that is, a group discussion technique designed to elicit involvement and commitment on the part of blue-collar workers, was developed. The current study evaluated a program which combined this "awareness session" technique with an incentive strategy similar to that used in previous research. The results indicated that this combination was very effective in motivating safety belt use among blue-collar workers, effecting an eight-fold increase in the percentage of seat-belt wearers. Implications regarding the use of social psychological principles in research in behavioral community psychology are discussed.

FINE MOTOR CONTROL AND THE EFFECTS OF BASAL GANGLIA LESIONS IN THE RAT. John V. Harrell, Dept. of Psych., Hampden-Sydney Col., Hampden-Sydney, Va. 23943  
The basal ganglia are thought to perform a ramp generation function necessary for control of slow movement, making it possible to refine the movement as it is being performed. To examine such a role for the basal ganglia in the rat, one group received bilateral caudate nucleus lesions and another group received control lesions in parietal cortex. The effects of these lesions were ascertained using a force-band/duration task. The task required the rats to limit the force of forelimb paw presses on a force transducer to a range of 20-50 gm and to hold this limited force response for a minimum of 1.5 sec in order to produce water reinforcers. Responses in which the duration requirement was not met or in which the force emission strayed from the preset range reset all response criteria. Results of the study indicate that rats with caudate nucleus lesions had extreme difficulty in limiting their force emissions to the required range of force but retained their ability to make the required response duration.

ESP IN THE CLASSROOM: PAST AND PRESENT. Ann W. Hill, Math Dept., Smithfield High Sch., Smithfield, VA 23430. This project was designed to achieve three goals: (1.) to get marked evidence of ESP from my candidate; (2.) to determine the extent of my participant's ability to display evidence of ESP by the old and new methodologies; (3.) to determine whether or not 'time' had an effect on ESP results if the psychological conditions were equal. There are students in our classrooms who possess extrasensory perception. My conjecture is that these students are special persons who have some kind of permanent, stable personality characteristic and mental attitude. My ultimate goal is to uncover these abilities and channel them into areas useful to the individuals.

SPATIAL LOCALIZATION IN THE MOUSE. L. E. Jarrard, Dept. of Psychology, Washington & Lee Univ., Lexington, VA. 24450, and A. Badgett\*, L. Draper\*, & H. Jarrard\*, Lexington High School, Lexington, VA. 24450.

In order to see if mice can learn to locate an object that remains in a fixed location relative to distal room cues, animals were trained in a Morris swimming task. The task consists of having the subjects swim in a circular pool filled with opaque water in order to find a "safe" platform. In the Place Condition the platform was in the same location from trial to trial just below the water surface thus eliminating visual and possible olfactory cues. In the Cue Condition the platform was visibly above the water surface but location varied over trials. Learning occurred rapidly in both groups of mice but significantly slower in the Place Condition. In order to see if the animals in the Place Condition were using spatial localization, a transfer test was carried out where the platform was moved to a new location. There was a resulting increase in swimming time thus demonstrating that the mice were not using local cues to find the platform. The data will be discussed in relation to recent theorizing concerning spatial memory in animals.

THE PaTE REPORT, A PSYCHODYNAMIC AND THERAPEUTIC EVALUATION. Lois S. Kriegman, The Kriegman Clinic, Ltd., 106 N. Thompson St., Richmond, Va. 23221 & George Kriegman, M.D.\* (deceased). This is a report of a procedure which had its origins in the authors' collaborative search for new techniques which can accelerate the therapeutic process and shorten the period of therapy necessary for the patient, whereby the emotional impairment and the economic loss to the individual, his family, and his community would be diminished. It was felt that if a quick penetration in depth into the basic core of the personality structure could be achieved, psychotherapeutic efforts could be more pointedly directed and the initial exploratory period in therapy diminished. The PaTE Report is a systematic psychological reporting procedure based on a testing technique and a particular theoretical orientation. It is an attempt to achieve the goal of a rapid psychodynamic and therapeutic evaluation of emotional problems. This report, derived from the scores of the Wechsler Intelligence Scales and Kahn Test of Symbol Arrangement, has been in constant use by the authors since 1959.

INDIVIDUAL AND COMBINED EFFECTS OF PHENCYCLIDINE, ETHANOL, AND NICOTINE ON LETHALITY IN RATS. P. M. Martin and W.T. Hodge, Dept. of Psychology, Va. State Univ., Petersburg, Va. 23803. The purpose of this experiment was to examine the lethality of PCP alone and in combination with two commonly used psychoactive drugs, ethanol and nicotine. Rats were given either 100, 125, or 150 mg/kg of PCP and the number of animals that died within 24 hours was recorded. The median lethal dose (LD50) for PCP was 127 mg/kg. The LD50 for PCP was then recalculated for rats predosed with nonlethal doses of ethanol or nicotine. When animals were predosed with ethanol (1000 mg/kg), the LD50 of PCP was 100 mg/kg, while the LD50 of PCP was 106 mg/kg for animals predosed with nicotine (60 g/kg). These were both significantly lower than the LD50 for PCP alone. These results show that both ethanol and nicotine enhance the lethality of PCP, thus suggesting that some of the toxic or lethal effects of PCP may be due to its interaction with other psychoactive drugs. This research was supported by NIH/MBRS Grant No. RR-08090-11.

A BEHAVIORAL PROFILE OF PHENCYCLIDINE IN THE RAT. P. Martin\*, D. Turner\* W. Hodge and R. Ferguson\*. Dept. of Psych, Va. St. Univ., Petersburg, Va. 23803. Since phencyclidine hydrochloride (PCP) acts as a dopamine agonist as do amphetamine and apomorphine, the purpose of the present experiment was to develop a behavioral profile for PCP which could be compared to those of amphetamine and apomorphine. Rats were given isotonic saline or 4, 8 or 16 mg/kg of PCP i.p. before being placed in an unfamiliar test cage. The frequency and duration of 10 behaviors were recorded using a double blind procedure during a 1 hr test session. PCP caused dose and time dependent decreases in sniffing and rearing and increases in swaying, locomotion and rotation. Although amphetamine and apomorphine increase locomotion and cause rotation as did PCP, these stimulants also increase, rather than decrease, rearing and sniffing behaviors in animals who have been adapted to the test chamber. Thus, the differences between these drugs may be due to either (a) different mechanisms of action or (b) an interaction between the drug and familiarity with the test environment. Rats who have been adapted to the test chamber are now being tested with the same doses of PCP to determine if such an interaction exists. This research was supported by NIH/MBRS Grant Number RR-08090-11.

OPERATIONAL DEFINITIONS: HELP OR HINDRANCE IN A MATURING SCIENCE? John L. Miles, Jr., U.S. Army Research Inst. for the Behavioral & Social Sciences, Alexandria, VA 22333. The concept of "operational definition" is taught to students as a means of aiding them in thinking clearly and expressing themselves in a way that can be readily understood by others who apply the scientific method. While thus a potential boon to certain scientists--particularly those who may wish to replicate a particular experimental situation--the existence of operational definitions can also have a divisive and retarding effect on the development of new technologies. This paper reviews the practical effects of proliferation of operational definitions within an area of psychology which describes human behavior in the form of "task analysis."

USING BIBLIOGRAPHIC TOOLS FOR INDIVIDUALIZING PSYCHOLOGY INSTRUCTION. James P. B. O'Brien, Div. of Social Sciences, Tidewater Cmnty. Col., Virginia Beach, VA 23456. Our pursuit of scientific research normally begins with a careful study of the literature. While we usually begin instruction in scientific method in an undergraduate's first course, developing the skillful use of the scientific literature is less systematic and provided piecemeal at the graduate level when presented at all. If our journals, handbooks, abstracts, and other reference works are vital in defining our problems, guiding our research, and organizing the knowledge of our discipline; it follows that their early purposeful introduction to students would be beneficial. The skills developed in using such basic tools will not only enhance their understanding of a particular science, but also will provide them with access to information useful in their daily lives. The argument is made that teaching these skills should not be delayed until the senior project or graduate school; nor should they be left to chance if we seek a wider, more cogent public awareness of science. Several examples in class handouts for a 3-quarter General Psychology course are distributed and discussed. Numerous learning principles including successive approximation, feedback, active student involvement, and the fostering of student initiative and responsibility are applied.

DEVELOPMENT OF A SUPPORT GROUP FOR FAMILIES OF STROKE PATIENTS. Ann R. Penberthy, Sandra Perosa,\* McGuire VAMC, Richmond, VA 23249

While patients recovering from stroke have noted difficulties in adjusting to the significant life changes associated with sudden and debilitating decrements in physical abilities, less attention has been paid to the parallel difficulties experienced by family members adjusting to concomitant changes in the family structure. Weekly meetings are held for emotional support of the families while the patients receive a concurrent speech therapy hour for practice of communication skills. As the support group developed, distinct patterns to the adjustment of family members were apparent. Discussion of these expected patterns with the new families joining the group has assisted in reduction of problems and a faster adjustment from the self-reports. Coping strategies utilized by the participants are discussed, and families have proved to be quite creative in developing a number of helpful activities to address the problems encountered. Research strategies to evaluate the impact of the support group activities on patient outcome variables and adjustment patterns of patients and family members were discussed. Implications for the development of similar support groups were considered.

THE CHALLENGE GROUP: COPING WITH CHRONIC ILLNESS. Ann R. Penberthy, Linda Perosa,\* and Marlene Dmytryshyn,\* McGuire VAMC, Richmond, VA 23249

The development of an inpatient open-ended support group for elderly chronically ill patients was described together with the research plans underway to obtain empirical data on the reports of improvement in adjustment, attitudes, and other psycho-social variables attributed to the impact of group therapy. The problems encountered in conducting groups on the medical wards include: staggered timing of admission and discharge, scheduling conflicts with OT, PT, RT, medical consults and family visits, memory losses for recent stroke patients. To accommodate these multiple disruptions, the groups leaders allocate several hours each week to scheduling arrangements, posting of names, and personal reminders to recently impaired group members. As a result, the group has been successfully maintained now for several months. Patients report that the discussions have been helpful in adjusting to the severe changes precipitated by sudden changes in health status, and associated reactions to decrements in chronic illnesses. Although the group size and composition changes weekly with the admissions and discharges, current members apparently develop a social support network that continues on the ward and facilitates adjustment of new patients.

**INCENTIVES AND SAFETY BELT USE: THE PROBLEM OF RESPONSE MAINTENANCE.** James R. Rudd\* & E. Scott Geller, Dept. of Psych., Virginia Polytechnic Inst., Blacksburg, Va. 24060. In the U.S. more than 34,000 deaths occur each year to occupants of passenger cars, light trucks, and vans. Safety belt usage could reduce the chance of injury by 50% or more. Unfortunately, the rate of safety belt use in this country is only 10%. Because of this low usage rate, the National Highway Traffic Safety Administration (NHTSA) formed an interdisciplinary committee to evaluate strategies for motivating seat belt use, which has included incentive programming. Incentive programs, which are based on reinforcement theory, have proven exceptionally successful in increasing safety belt use -- increases of 100% or more are not uncommon. However, when the incentive programs are withdrawn, belt usage often returns to baseline levels. This paper is a theoretical discussion of possible solutions to this problem of response maintenance. Ongoing programming (STEP theory) and commitment vs. incentive programs are discussed along with related factors such as observer bias, the Hawthorne Effect, and treatment packages.

**THE DRUNK-DRIVING PROBLEM: TOWARD A COMMUNITY-BASED PROGRAM.** Ann E. Talton\*, Mark Altomari\*, and E. Scott Geller, Dept. of Psychology, Va. Polytech. Inst., Blacksburg, Va., 24061. Efforts to reduce alcohol-impaired driving have traditionally focused on education, legislation, and rehabilitation. To date, such strategies have been relatively unsuccessful. In an effort to depart from traditional interventions, an assessment plan was designed to gauge the drunk-driving problem in a university community. As a first step, several questionnaires were constructed and administered to 355 students at Va. Tech. These were designed to tap students' opinions and attitudes toward various aspects of alcohol use in college and particularly to issues related to drunk-driving. Results will be discussed along with implications for comprehensive communitywide interventions to reduce drunk-driving.

## Statistics Section

**TWO-TAIL TESTS vs. TWO-ALTERNATIVE TESTS.** Robert L. Andrews, Dept. of Business Administration, Virginia Commonwealth University, Richmond, VA 23284. We are creatures of habit. We often are not open to examining procedures that differ from those that we were taught. When we do examine something different we carry a lot of baggage and prejudice into the examination. This paper compares the customary one-tail or two-tail hypothesis tests with a two-alternative procedure. The comparison emphasizes the perspective of the student who has not been biased by previous education. The author finds the two-alternative test to be a superior procedure. The final question is, "Which procedure should we teach?"

**NONPARAMETRIC ONE-SAMPLE BAYESIAN INFERENCE.** David L. Banks, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va., 24061. Suppose one wishes to perform a one-sample hypothesis test about a general parameter when the underlying distribution is known to have finite support on a given interval. In this situation it is possible to develop a nonparametric test that adheres to the principles of sufficiency, conditionality and likelihood, and which permits the statistician to employ prior information in a flexible manner. The development depends on the imposition of a measure on a suitable subset of the space of measures; for best results, this prior measure should combine a roughness penalty with an appropriate weighting scheme. This leads to a persuasive Bayesian test, and there are immediate multivariate extensions.

**NORMAL TOLERANCE LIMITS: A STUDY OF ROBUSTNESS.** George C. Canavos, School of Business, Virginia Commonwealth University, Richmond, VA 23284. Robustness properties of the two-sided tolerance limits for normal distributions are examined based on a computer simulation in which the Student's  $t$  and gamma distributions are used as generating models. Results indicate that the normal tolerance limits are sensitive to departures from normality when  $k$ -factors are selected for coverages in excess of 0.9. Reasonable robustness is achieved for coverages of at most 0.9, as long as the underlying distribution is not extremely long-tailed nor highly skewed.

**A CONFIDENCE INTERVAL ON THE RESPONSE AT THE OPTIMAL LEVELS OF THE INDEPENDENT VARIABLES IN A RESPONSE SURFACE.** Walter H. Carter, Jr.\*, Vernon M. Chinchilli\*, Eleanor D. Campbell\*, Dept. of Biostat., Va. Commonwealth Univ., and Galen L. Wampler\*, Dept. of Medicine, Va. Commonwealth Univ., Richmond, Va. 23298. This paper presents a method for calculating a confidence interval about the response at the stationary point of a response surface. It is shown that the technique can be used also to calculate a confidence region about the location of the stationary point. The procedure is applied to the analysis of survival data via Cox's proportional hazards model of two preclinical cancer therapy experiments. The first experiment involves a single drug while the second evaluates a combination of two drugs. The results are discussed in terms of treatment activity and therapeutic synergism.

**ANALYSIS OF COVARIANCE IN THE MULTIVARIATE GROWTH CURVE MODEL.** Vernon M. Chinchilli, Dept. of Biostatistics, Va. Commonwealth Univ., Richmond, Va. 23298. The multivariate growth curve model fits a polynomial growth curve for repeated measurements of a response variable. If the experimental units have been randomized to  $k$  treatment groups, then  $k$  distinct polynomial curves of the same degree can be inserted into the model. Usually it is of interest to compare statistically the  $k$  growth curves. In some experimental situations it may be necessary to adjust for covariables. The multivariate growth curve model can adjust for covariables by categorizing them into  $m$  strata and then modeling  $mk$  polynomial curves. This results in too many parameters for estimation and too few error degrees of freedom for hypothesis testing. An extension of the multivariate growth curve model has been developed which permits the use of covariables in a manner analogous to the classical MANCOVA model.

**SIMULTANEOUS RANDOMIZATION TESTS.** Robert V. Foutz\*, Dept. of Stat., Va. Polytechnic Inst., Blacksburg, VA 24061. Randomization analyses have been developed for testing main effects and interactions in standard experimental designs. However, exact multiple comparisons procedures for these randomization analyses have yet to be treated. This article proposes a general procedure for constructing simultaneous randomization tests that have prescribed type I error rates. An application of the procedure does provide for multiple comparisons in the randomization analyses of designed experiments. This application is made to data collected in a biopharmaceutical experiment.

THE EFFECT OF BIAS, VARIANCE ESTIMATION, SKEWNESS, AND KURTOSIS OF THE EMPIRICAL LOGIT ON WEIGHTED LEAST SQUARES ANALYSES. John J. Gart, Hugh M. Pettigrew, and Donald G. Thomas, Biometry Br., National Cancer Institute, Bethesda, MD. 20205. The first four cumulants of empirical logit transformation of binomial variates are studied exactly and in asymptotic expansions. The covariance of the empirical logit and its estimated variance is also considered. The  $\pm 1/2$  corrections are found to be not universally effective in reducing bias. Other corrections are suggested for simple logistic regression and the estimation of a common odds ratio in several  $2 \times 2$  tables. The distribution of the empirical logit is more skewed and has a larger kurtosis than the binomial. Confidence interval methods based on binomial variates, such as Cornfield's limits for the odds ratio, have better properties than empirical logit methods. Methods based directly on sufficient statistics or functions thereof, such as the maximum likelihood estimators corrected for asymptotic bias, are recommended.

USE OF CONFIDENCE REGIONS FOR TESTING HYPOTHESES IN CLINICAL TRIALS. Janis L. Goodlow\*, Dept. of Biostatistics, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va 23298. At the present time combination chemotherapy may be less effective than it is capable of being. Current methodology depends on the investigator making an educated and fairly accurate estimate as to what the optimal treatment level(s) are. Presented here is a new approach that does not rely as heavily on an investigator's intuition. This approach is a combination of survival analysis, response surface analysis and design of experiments. The effects on the procedure of varying the conditions upon which the assumptions are based are investigated. This procedure has the potential of yielding information concerning drug action and interaction that may aid in the development of improved clinical protocols. (Aided by Grant IN-105H from the American Cancer Society.)

COLLINEARITY IN SIMULTANEOUS SYSTEMS. William D. Grubbs & Oral Capps, Jr., Dept. of Stat., Va. Polytechnic Inst., Blacksburg, Va 24061. Many situations in quantitative economic analysis cannot be modeled under the principle of unidirectional flow of causality, as is common with many types of analyses in the physical sciences. Simultaneous systems of equations are commonly used to describe economic phenomena. Simultaneous systems are classified according to the concept of identification, and many systems are classified as over-identified. A popular technique for dealing with over-identified systems of equations is Two Stage Least Squares (2SLS). As least squares suffers from imprecise estimation when ill-conditioned data have been collected, so does 2SLS in a simultaneous system framework. Techniques have been proposed to circumvent ill-conditioning, using variants of the popular ridge regression and principal component regression procedures, as adapted to 2SLS. It is hoped that these estimators have smaller mean squared error than the 2SLS estimator. Simulation studies involving ridge regression in both stages of 2SLS are being conducted.

LOG-LINEAR MODEL ANALYSIS OF THE ASSOCIATION BETWEEN DISEASE AND GENOTYPE. K. Hinkelmann, Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061 & H.J. Khamis\*, Department of Statistics, Wright State University, Dayton, OH. Further insight into the analysis of the disease-genotype association problem, as discussed by Norwood and Hinkelmann (1978), is provided through the use of the log-linear model. It is shown how this approach can take the structure of the data into account for testing hypotheses about the type of association, specifying the form of recurrence risks, and estimation of such recurrence risks by maximum likelihood. The notion of conditional recurrence risk is introduced and its usefulness is illustrated.

VARIANCE REDUCTION TECHNIQUES USING RESPONSE SURFACE DESIGNS. James R. Hussey & Raymond H. Myers, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061. In computer simulation studies, the experimenter can control conditions in the system. One example is the ability to induce positive and negative correlations among the observations, rather than using independent observations. This can be done using the techniques of common variates and antithetic variates. These correlations alter the variance-covariance matrix of the design employed in the experiment. Although many possible correlation structures exist, certain patterns emerge as being more beneficial than others. These patterns can be viewed as the design being separated into blocks, where the correlations define the blocking. With these patterns, variance reduction is realized in many cases, especially in designs which admit orthogonal blocking. Variance is measured by prediction variance, integrated variance, and other criteria. Common response surface designs of first and second order are considered, with generally favorable results.

CELL MEANS ANOVA OF TWO-WAY LAYOUTS: A GEOMETRIC VIEW. Robert E. Johnson, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, Va. 23284. Yates (1934) presented a method of analysis of two-way, fixed effects designs using as the one observation per cell the estimated cell mean and derived an approximate F test utilizing an adjusted mean squared error. This procedure, known as the unweighted means analysis, can be seen as a quite natural one when viewed geometrically. Via the geometric approach, conditions for independence of sums of squares and for exact F-distributions of variance ratios will be given in terms of some measures of nonorthogonality.

DISPUTED PATERNITY. Stephen P. Mandel\*, Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. The following situation arises alarmingly often: a lady claims that Mr. X is the biological father of her child; Mr. X says that he is not. This leads to a dispute that sometimes can only be settled in the law courts. Counsel for Mr. X would first try to clear his client by attempting to demonstrate a genetic incompatibility between Mr. X and the child. For instance, if he has blood group O and the child has AB then he could not have sired that child and would (now) be acquitted on the basis of that evidence. The ramifications will be discussed.

REDUCING TRANSFORMATION BIAS IN CURVE FITTING. Don M. Miller, School of Business, Va. Commonwealth Univ., Richmond, Va. 23284. A variety of methods exist for modeling a non-linear relationship between two variables. For what is probably the most common method in practice, linear regression analysis is applied to the variables after they have first been linearized by a transformation. The curve is then obtained by applying the inverse transformation to the fitted line. However, this procedure produces what can be a serious bias. This bias is identified for each of a simple set of transformations which provide satisfactory linearization for a large number of applications. Simple adjustments are presented which greatly reduce these biases.

THE MULTIPLE DESIGN MULTIVARIATE LINEAR MODEL. Barry H. Schwab\*, Dept. of Biostatistics, Med. Col. of Va., Richmond, Va. 23298. The multiple design multivariate (MDM) linear model can be applied to a multivariate regression system with polynomial models of different degree in the dependent variates. Zellner (1962) considered a method of estimating the parameters of a multivariate regression system falling under the MDM model. The procedure applies Aitken's generalized least-squares to the whole system of equations to simultaneously estimate the regression coefficients. I will investigate whether the estimation technique can be improved by performing an iterative extension to Zellner's least-squares algorithm.



STOCHASTIC FLOW SHOP WITH BLOCKING. S. Suresh, Dept. of Industrial Engineering and Operations Research, Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Pinedo has conjectured that in a stochastic flow shop with  $m$  machines,  $n-2$  deterministic jobs with unit processing time, and two stochastic jobs with mean one, the optimal sequence to minimize the expected makespan is to schedule one of the stochastic jobs first and the other last. We prove that the optimal sequence is either the sequence of Pinedo's or the sequence in which the stochastic jobs are adjacent at one end of the sequence.

CONFIDENCE INTERVALS FOR CEP ESTIMATORS WITH ELLIPTICAL NORMAL ERRORS. Audrey E. Taub\* and Marlin A. Thomas\*, Mathematical Statistics Staff, Naval Surface Weapons Center, Dahlgren, VA 22448. A common parameter for describing the accuracy of a weapon is the circular probable error, commonly referred to as CEP. CEP is defined as the radius of a mean centered circle within which 50% of the future rounds from a particular weapon system will fall. If the fall of shot follows an elliptical normal distribution, a number of estimators exist for estimating CEP. This paper develops approximate confidence intervals for each of five commonly used CEP estimators.

## NOTES



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U.S. National Arboretum  
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✓  
**Intergradation Among Ringneck Snakes,  
*Diadophis punctatus* (Linnaeus) in Virginia**

**Charles R. Blem and Cheryl Roeding**

Department of Biology  
Academic Division  
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Richmond, Virginia 23284

ABSTRACT

Two subspecies of the ringneck snake, *Diadophis punctatus*, exist in Virginia. Conventional taxonomic characters supported by multivariate morphometric analyses indicate that southeastern Virginia represents the northeastern extreme of the zone of intergradation between the southern ringneck snake, *Diadophis p. punctatus*, and the northern ringneck snake, *D. p. edwardsii*. Only the population from the extreme southeastern part of the state (Suffolk, Norfolk, and Virginia Beach) shows little evidence of intergradation. Ringneck snakes from the northern coastal plain and remainder of the state are *D. p. edwardsii*. Individuals collected from within a triangle formed by the James River, fall line, and the southern Virginia border are intergrades. Characters of high validity for separating the subspecies in Virginia are prominent ventral spots and neck rings. Labial/chin spotting is not useful in this regard.

INTRODUCTION

The ringneck snake, *Diadophis punctatus*, is a relatively small, secretive snake found throughout much of the eastern United States (Blanchard, 1942; Paul, 1967). Two subspecies occur in Virginia; the northern ringneck snake, *D. p. edwardsii* (Merrem), and the southern ringneck snake, *D. p. punctatus* (Linnaeus). Conant (1946) described their distribution and area of intergradation on the Delmarva Peninsula and Paul (1967) examined the distribution of both subspecies in much of the rest of the southeastern United States. Conant and Paul described populations in southeastern Virginia as *D. p. punctatus*, but confusion still exists as to the precise range and area of intergradation of the subspecies. Conant (1975; map 133) indicated that *D. p. punctatus* occurs throughout much of the coastal plain, and included localities for *punctatus* as far north and west as Richmond. Martof et al. (1980) stated that individuals with incomplete neck rings (= *D. p. punctatus*) occupy "the coastal plain of North Carolina and Virginia". A relatively large number of specimens now available permits a more precise analysis of the range limits and identification of these

subspecies. The following study was undertaken to clarify the distribution, systematics and zone of intergradation of ringneck snakes in Virginia.

#### MATERIALS AND METHODS

Specimens (N = 172) were examined from the American Museum of Natural History (14), Carnegie Museum (49), U. S. National Museum (79), and Virginia Commonwealth University Vertebrate Collection (30). Ventral and subcaudal counts, snout-vent lengths and tail lengths were obtained from all specimens except for 10 that were missing part of the tail. Ventral spotting patterns, condition of the neck ring (complete or incomplete), and labial spotting were noted where appropriate. Data were compiled, sorted, and analyzed by computer. Individuals from single counties or clusters of contiguous counties were grouped subjectively and mean scale counts and frequencies of punctatus/edwardsii characters were calculated by locality (Figs. 1-3). Extent of geographic areas represented by each group were roughly similar. Statistical analyses were performed by the Statistical Analysis System (SAS Institute, 1982).

#### RESULTS AND DISCUSSION

Four characters traditionally have been used to distinguish D. p. punctatus from D. p. edwardsii. Among the punctatus characters are: (1) chin or labial spots, (2) a neck ring interrupted mid-dorsally, (3) prominent ventral spots, and (4) a total of ventral plus subcaudal scales of 190 or less (Blanchard, 1942; Paul, 1967; Martof et al., 1980). Blanchard (1942) reported that ventral scale counts tend to be lower in punctatus than in edwardsii (punctatus males, 127-150, edwardsii males, 139-162; punctatus females, 134-155, edwardsii females, 146-176), although the difference is not diagnostic by itself. We have used conventional methods in coordination with multivariate techniques to determine how precisely the identity of Virginia specimens might be established using all of these characters.

Table 1 summarizes the frequency of occurrence of each character and the frequency of overlap of punctatus/edwardsii criteria. Labial spots are the least reliable of the punctatus characters; of 53 individuals possessing only one punctatus character, 46 also had labial spots (Fig. 1). Snakes with only one punctatus character (ignoring labial/chin spots) were found in Mecklenburg, Surry and Henrico counties. Labial spotting occurs in specimens from throughout the state (Fig. 1), is not particularly associated with either subspecies, and therefore is not useful in identification. Individuals with two punctatus characters were obtained from Chesterfield and Southampton counties and "Nansemond" (now a part of Suffolk) and Suffolk. All seven individuals with three punctatus characters were also from southeastern Virginia (Southampton county, Suffolk, Virginia Beach). Only 9 D. p. punctatus were in the sample and all were collected in extreme southeastern Virginia (Suffolk, Norfolk and "Princess Anne county" = Virginia Beach).

The best single character for separating punctatus from edwardsii appears to be the presence in the nominate subspecies of prominent ventral spots approximately 1/2 the width of the ventral scales. Although ventral spots occur on snakes from over a wide geographic range (91 of 172 individuals have some sort of ventral spots), prominent spots are restricted to

Table 1. Frequency of punctatus and edwardsii characters in Virginia ringneck snakes (P = punctatus character; E = edwardsii; \*10 specimens were missing part of the tail).

Character	N
Incomplete ring (E)	11
Complete ring (P)	161
Labial spots (P)	57
No labial spots (E)	115
Heavy ventral spots (P)	19
Spots small or absent (E)	153
Ventrals + subcaudals	193
Ventrals + subcaudals	192
Specimens having: *	
All <u>punctatus</u> characters:	8
Three <u>punctatus</u> characters:	5
Two <u>punctatus</u> characters:	6
One <u>punctatus</u> character:	53
All <u>edwardsii</u> characters:	86

Table 2. Comparison of ventral plus subcaudal counts with occurrence of ventral spotting (V), neck ring configuration (R) and labial spotting (L). E = edwardsii condition; P = punctatus condition. Ten individuals with incomplete tails were omitted.

V	Character		N	Ventrals + subcaudals	
	R	L		Mean	Range
P	-	-	17	185.4	175-195
E	-	-	145	208.0	183-229
P	P	-	9	186.1	180-192
P	E	-	8	184.5	175-195
E	E	-	145	208.5	186-229
P	-	P	12	184.8	175-192
P	-	E	5	186.7	183-195
E	-	P	42	208.9	183-222
E	-	E	103	207.6	186-229
P	P	P	8	185.9	180-192
P	P	E	1	188.0	---
P	E	P	4	182.5	175-190
P	E	E	4	186.5	183-195
E	P	P	0	---	---
E	P	E	0	---	---
E	E	P	42	208.9	183-222
E	E	E	102	207.6	186-229

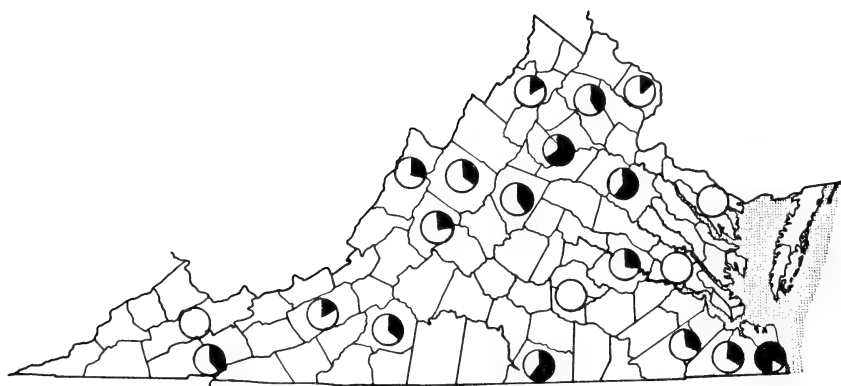
snakes collected from extreme southeastern Virginia. The condition of the neck ring is also a high-validity criterion, but only 11 individuals with incomplete neck rings were obtained. All were from Virginia Beach, Suffolk or Norfolk. The condition of neck rings is a more continuous variable than portrayed here. Some complete rings are narrowed mid-dorsally, suggesting intermediate stages between complete and incomplete rings. A third good criterion is the sum of ventral plus subcaudal scales, although we disagree with Paul's (1967) choice of 190 as a separation point for the subspecies. Two specimens with counts of 192 also had punctatus neck rings and ventral and labial spots. Low ventral plus subcaudal counts are highly correlated with punctatus characters (Table 2).

Principal components analysis (Sneath and Sokal, 1973) was used to further examine variation in punctatus/edwardsii characters. These included condition of the neck ring (+/-), ventral and labial spotting (+/-), numbers of ventrals and subcaudals, and total of subcaudals plus ventrals as described above. We also included tail length/snout-vent length ratios and snout-vent lengths, as these have been suggested to be of at least marginal importance in separating the subspecies (Blanchard, 1942; Paul, 1967). Only ventral, subcaudal, and total (ventral plus subcaudal) counts, condition of the neck ring, and ventral spotting were useful in separating the subspecies.

Positive loading (Sneath and Sokal, 1973) was obtained for all variables except ventral spotting. Labial spotting was not useful in separating the subspecies; similar separation was obtained with this character omitted from the analyses. Most (76%) of the variation was accounted for in the first two principal components. Canonical correlation analysis (Blackith and Reyment, 1971) was next applied to this data set. Fairly sharp separation of individuals without mixed characters was obtained, with intergrades falling between these (Fig. 5). All individuals identified as intergrades in the conventional manner fell in the intermediate zone. Five specimens from the northeastern and central coastal plain of North Carolina included in the analysis as controls appeared in the punctatus cluster.

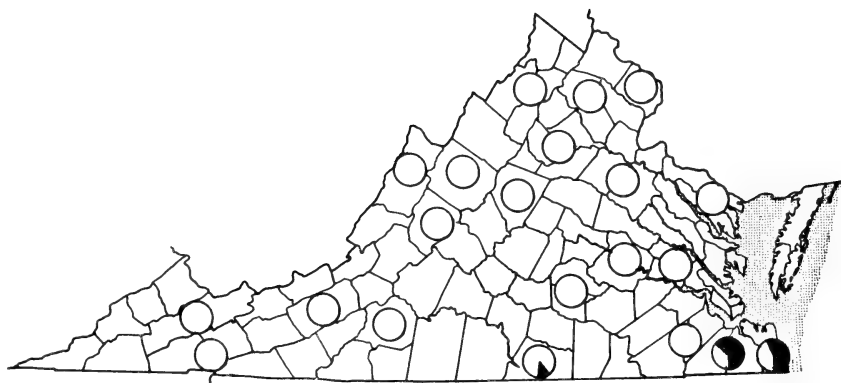
Relatively few intergrades were identified in this study because: (1) few specimens exist from the zone of intergradation, (2) the zone of intergradation apparently is relatively small in Virginia, and (3) the James River and fall line are relatively effective barriers to gene flow. We believe the zone of intergradation from punctatus to edwardsii largely is restricted to southeastern Virginia and is readily distinguishable (Fig. 4). To determine where the zone ends, we graphed the first and second principal components, extracted from the matrix of variables described above, as a function of distance from the nearest specimen of punctatus showing no sign of intergradation. Most of the gradient between punctatus and edwardsii is completed in the first 150 km northward and westward from the edge of punctatus range (Fig. 6). No further gradient in punctatus/edwardsii characters is apparent north of the James River and west of the fall line. Even ventral plus subcaudal counts show no general trends in this area (Fig. 3). The roles of the barriers to gene exchange are problematic; the James River varies from about 1 to 15 km wide in the coastal plain of Virginia and therefore should prevent or restrict gene exchange along a north-south axis. However, the barrier that the fall line provides is not so clear. This barrier is nevertheless real; several species of amphibians and reptiles which are common in the coastal plain, appear to violate this boundary infrequently (or never).

We conclude that the southeastern part of the state from



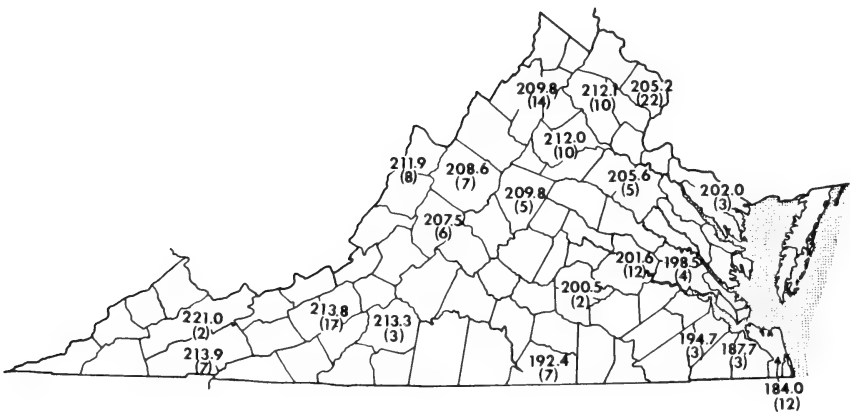
**Fig. 1**

Distribution of individuals with labial spotting. The shaded segment of the circle represents the relative frequency of spotting. For sample sizes, see Fig. 3.

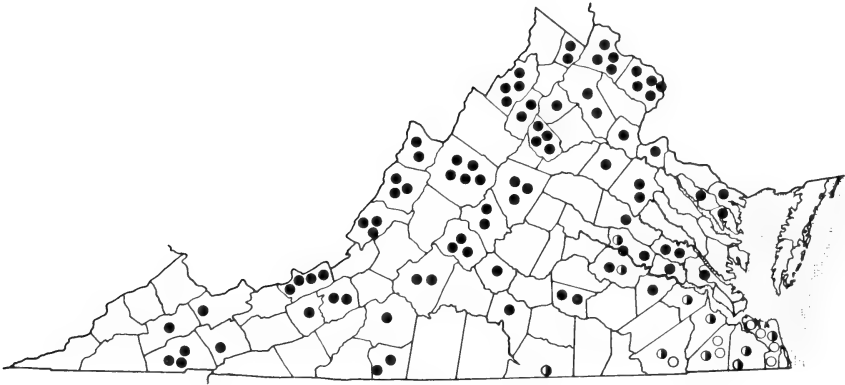


**Fig. 2.**

Distribution of individuals having prominent ventral spots. Circles are as in Fig. 1.



**Fig. 3**  
Distribution of mean ventral plus subcaudal scale counts. Sample sizes are in parentheses.



**Fig. 4**  
Distribution of *Diadophis punctatus* in Virginia. Solid circles represent *D. p. edwardii*, hollow circles represent *D. p. punctatus*, and half-shaded circles represent intergrades. Some dots represent more than one specimen collected from a single locality.

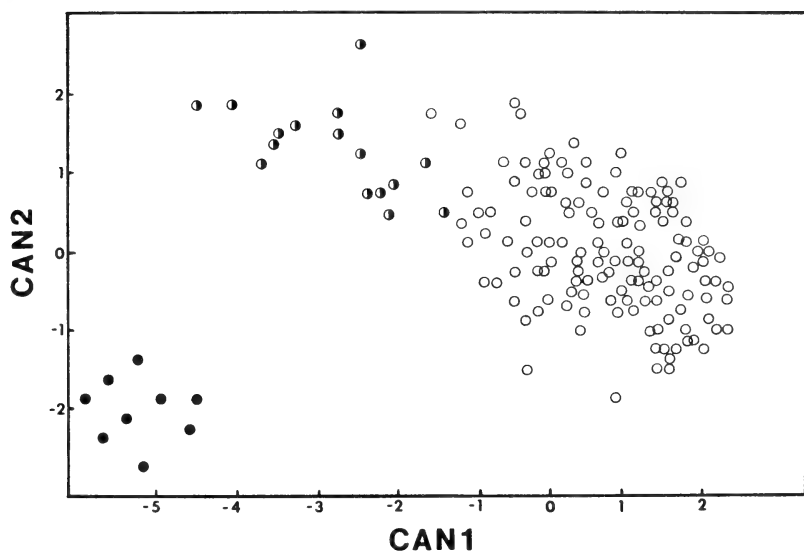


Fig. 5

Canonical correlation analysis of ringneck snakes. Solid circles represent *D. p. punctatus*, hollow circles represent *D. p. edwardsii*, and half-shaded circles represent intergrades.

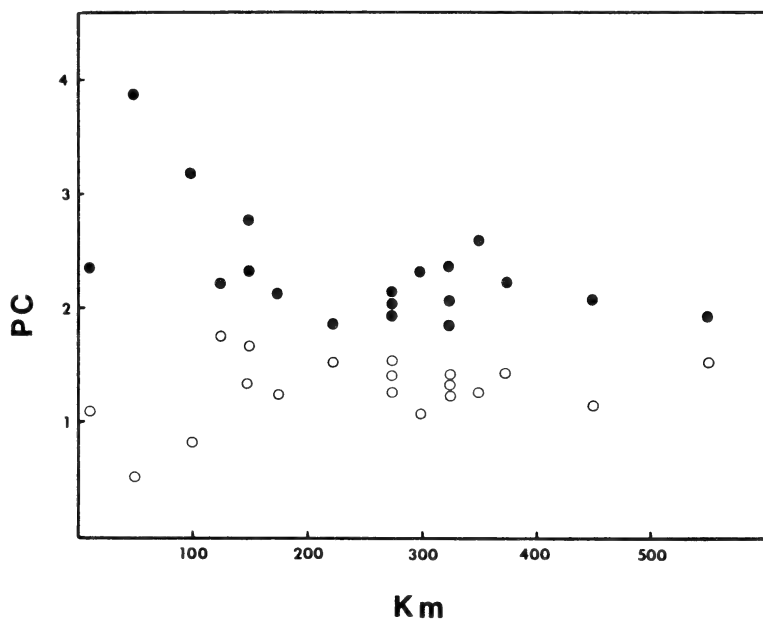


Fig. 6

Variation in principal components (PC) as a function of distance from *D. p. punctatus* range. Solid circles represent principal component I, hollow circles, principal component II.

Virginia Beach northward to the James River and westward through the fall line represents the zone of intergradation between the subspecies of ringneck snakes in Virginia. Individuals from this area always possess one to four punctatus characters. Only rarely are punctatus characters encountered north and west of those boundaries. Excluding the highly unreliable labial spotting as a punctatus character, only three specimens with punctatus characters were recorded in the range of edwardsii (Henrico, Chesterfield and Mecklenburg counties; see Fig. 4). Extreme southeastern Virginia is not outside the zone of intergradation; some specimens possessing edwardsii characters have been collected there.

#### ACKNOWLEDGMENTS

We are indebted to the following for the loan of specimens: Joan C. Dudley and Roy W. McDiarmid of the U. S. National Museum, George W. Foley of the American Museum of Natural History, and E. J. Censky of the Carnegie Museum. John F. Pagels and Leann Blem provided helpful, critical reviews of the penultimate version of this manuscript.

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**Phytoplankton Studies Within the Virginia Barrier Islands.  
III. Phytoplankton Composition in a Saline Pond  
on Smith Island.**

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ABSTRACT

The phytoplankton that characterized the Smith Island pond was diverse, with several species of diatoms, dinoflagellates, and bluegreen algae dominant throughout the year. A total of 146 species were noted, predominantly composed of ultra and nanoplankters, that includes representatives from coastal waters. The island ponds are considered eutrophic habitats whose composition is influenced by overwash conditions and in turn introduce populations to surrounding pools and water channels.

INTRODUCTION

Previous reports in this series presented the seasonal phytoplankton composition and population changes for Goose Lake, a small oligohaline lake located on Parramore Island, and the water channels among several of the Virginia Barrier Islands (Marshall, 1980; Marshall et al., 1981). A total of 154 species were noted in Goose Lake, where the populations were dominated by ultra and nanoplankton, with diatoms, chlorophyceans and cyanophyceans most common. Populations within the waterways were similar to offshore phytoplankters, and diatoms predominated throughout the year.

Smith Island is one of the southern most Barrier Islands located along the eastern coastline of the Delmarva Peninsula. It is in Virginia, located directly northeast of Cape Charles, between Fisherman and Myrtle Islands. Smith Island is approximately 12 km in length with an average width of about 0.85 km. A dune ridge is present on the seaward side, with a series of numerous, parallel and vegetative ridges in the southern end of the island. Extensive marsh and mud flats compose major portions of the island from the northern end southward to about 3/4 of its length. Higher elevation characterizes the southern portion, with salt marsh and scattered ponds located between the interior dune ridges. Based on field observations, a pond was selected in this southern sector as representative of the numerous ponds that characterize this low land area. This is a permanent pond, elongated in shape, varying in width from 1.5 to 3.5 meters and approximately 80 meters long, with a maximum depth of 0.65 meters. It is located within an open area, surrounded by wetlands plants (e.g. *Spartina alterniflora*, *Spartina patens*, *Distichlis spicata*), but contains no standing or submerged vegetation. The pond bottom is black in color, composed of a high silt composition mixed with sand and strands of the surrounding vegetation in various stages of decay. Upon disturbing the bottom substrate,  $H_2S$  is commonly

noted. The pond water is usually light amber in color. Salt water intrusion occurs during high storm tides. Fluctuations in water depth were also noted during the year, being mainly influenced by periods of high precipitation and subsequent drainage into the pond, or the occasional tidal entry. Throughout the sampling period there was standing water present, with the lowest pond depth being 0.35 m.

The purpose of this study is to present the phytoplankton composition for one of the permanent ponds within the Virginia Barrier Islands complex. This is a common habitat within the island complex that represents a unique ecological setting for pond study. Seasonal assemblages and dominant species will be discussed for spring, summer, and fall months.

#### METHODS

Collections were taken during ten trips to Smith Island from 7 October 1981 to 9 October 1982. Two other trips during winter were aborted due to inclement weather conditions. Surface water samples (500 ml) were preserved immediately with a buffered formalin solution. A settling and siphoning procedure was followed to obtain a 20 ml concentrate which was subsequently examined in a settling chamber of a Zeiss inverted plankton microscope. Salinity readings were taken with a portable Beckman salinometer.

#### RESULTS AND DISCUSSION

The Smith Island pond would be classified as mixohaline, with a wide range of salinity values through the year. Those recorded during this study ranged from 12 to 30‰, with the majority of values less than 22‰. A total of 146 species were identified for this pond and are given in Table 1. The total phytoplankton was dominated numerically by small diatoms, cyanophyceans, and chlorophyceans. Maximum concentrations occurred during the summer, with greatest diversity of species in the fall and lowest concentrations in spring. No collections were made during winter.

Several patterns found in this pond study compare closely to those observed at Goose Lake on Parramore Island (Marshall, 1980). Summer was the period of highest cell concentrations with the dominant species in the ultra- and nanoplankton size categories. Several *Cyclotella*, *Anacystis*, and *Chlorella* species composed the prominent ultraplankton in both habitats. *Gymnodinium danicans* was also the dominant dinoflagellate at Goose Lake, but the dinoflagellates were more abundant and diverse at the Smith Island pond. Species in low concentrations, but seasonally common were *Amphora* sp., *Cylindrotheca closterium*, *Nitzschia longissima*, *Tropedoneis lepidoptera*, *Ochromonas* sp. and *Anacystis cyanea*. Approximately 40% of the species in the Smith Island pond were also noted in the Goose Lake study. Those phytoplankters that were only recorded in the pond were the more typical estuarine and marine types indicative of saltwater intrusion. In contrast, the species recorded at Goose Lake, but not in the pond, consisted of common lake species from the Atlantic coastal plain represented by broader representation from the chlorophyceae, euglenophyceae, and a different assemblage of bacillariophyceae. The greater influence of salt water intrusion was evident in the phytoplankton composition of the Smith Island pond. In contrast to these results, Nemeth (1969) observed a variety of chlorophyceans and cyanophyceans in eight fresh water ponds during a summer survey on Delmarva Peninsula. The dominant populations included a variety of desmids, *Scenedesmus* spp., *Tetradron* spp., and *Spirogyra* spp. that were not found in the Smith Island Pond. The Cyanophyceae assemblage reported by Nemeth was also different, being characterized by numerous filamentous forms (e.g., *Oscillatoria* spp., *Phormidium* spp., and *Anabaena* spp.). In the Smith Island Pond, the dominant Cyanophyceae included *Nostoc commune*, *Lyngbya aestuarii*, and *Spirulina subsalsa*.

Further attention is needed for the unidentified category of cells noted in this study, which were grouped according to size ( $<3\text{ }\mu\text{m}$ ,  $3\text{--}5\text{ }\mu\text{m}$ ). Most of these appeared to be either cyanophyceans or chlorophyceans. They were generally spherically to oblong in shape, non-flagellated, green in color, with a smooth surface. Species distinction within these cells, and within the *Chlorella* and *Anacystis* groups is often difficult. The author questions the separation of several of these into multiple species categories and supports the re-evaluation of the marine *Chlorella* species (*C. marina*, *C. salina*) and the status of *Nannochloris atomus* as discussed by Sarokin and Carpenter (1982). Gradations are common in this *Chlorella* "complex" and these forms appear to be habitat variations of *Chlorella vulgaris*.

In addition to the phytoplankton populations in Smith pond, mention of the prominent zooplankton fauna should be given. The zooplankton was dominated by rotifers, various nauplii stages, calanoid copepods, nematodes, and ciliates, with the occasional appearance of polychete and dipteran larvae. During the fall *Keratella cochlearis*, *Brachionus* sp., *Cephalodella* sp., and nauplii were most abundant. In late fall and early spring, nauplii, adult calanoid copepods, and nematodes were common. During the summer *Lecane* sp., *Cephalodella* sp., nauplii and nematodes were in high concentrations. The extent of the grazing influence of these zooplankton populations in determining the phytoplankton composition is unknown.

In summary, the Smith Island pond was mixohaline, shallow in depth, and lacking in submerged, and emergent vegetation. A permanent standing water habitat throughout the year, the phytoplankton composition was diverse, with ultra and nanoplankton sized species most abundant. The dominant species included diatoms, a chrysophycean, and a variety of cyanophyceans. These bluegreen algae have as a common dominant several *Anacystis* spp. along with a variety of filamentous species. The composition was also different from assemblages reported for fresh water ponds on Delmarva Peninsula.

The Virginia Barrier Islands contain a vast number of standing water habitats similar to the Smith Island pond. These sites and their biota are influenced throughout the year by overwash conditions which augment the population and assure the repeated entry of saline waters. The ponds receive drainage from the surrounding area, have a rich organic substrate, and frequently are visited by water fowl and small mammals that through defecation add to the nutrient base of the ponds. The populations that persist within these habitats are diverse, are mainly represented by small-sized species capable of a fast growth response, commonly found in high concentrations. These characterize an eutrophic condition within these pond habitats. The overwash conditions that flood these ponds will also influence the spreading of pond populations over the lower wetlands area to seed other ponds on the island, and to transport populations to the island channels and coastal waters. This inoculation and enrichment process functions in both landward and seaward directions, producing gradations of population similarities in the island ponds and coastal waters.

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Table 1. Phytoplankton identified in the Smith Island pond. Presence is noted with X; the more abundant species are indicated by A, B, C, with A being the most abundant.

	7 Oct 81	18 Oct	22 Nov	9 Mar 82	14 Apr	26 Jun	10 Jul	7 Aug	18 Sep	9 Oct
<u>BACILLARIOPHYCEAE</u>										
<i>Amphiprora</i> sp.	X	-	-	X	-	-	-	X	-	-
<i>Amphiprora alata</i> (Ehrenberg) Kützing	X	X	X	X	-	-	X	-	-	-
<i>Amphiprora pulchra</i> Bailey	X	-	-	-	-	-	-	-	-	-
<i>Amphora</i> sp.	X	X	X	X	X	-	X	X	X	X
<i>Amphora coffeaeformis</i> Kützing	-	-	-	-	X	-	-	-	-	-
<i>Amphora granulata</i> Gregory	X	X	-	-	-	-	X	-	-	-
<i>Asterionella glacialis</i> Castracane	-	X	-	-	-	-	-	-	-	-
<i>Asterionella notata</i> (Grunow) Grunow	-	X	-	-	-	-	-	-	-	-
<i>Auricula complexa</i> (Gregory) Cleve	X	-	X	-	-	-	-	-	-	-
<i>Bacillaria paxillifer</i> (Muller) Hendey	C	X	X	X	-	-	-	-	-	X
<i>Biddulphia sinensis</i> Greville	-	X	-	-	-	-	-	-	-	-
<i>Caloneis westii</i> (Smith) Hendey	-	X	-	-	-	-	-	-	-	-
<i>Chaetoceros curvisetum</i> Cleve	-	X	-	-	-	-	-	-	-	-
<i>Chaetoceros debilis</i> Cleve	-	A	-	-	-	-	-	-	-	-
<i>Chaetoceros sociale</i> Lauder	-	-	-	-	-	-	-	-	-	X
<i>Cocconeis</i> sp.	-	X	-	-	-	-	-	-	-	-
<i>Coscinodiscus</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Cyclotella</i> sp.	X	X	C	X	-	C	-	X	-	A
<i>Cyclotella caspia</i> Grunow	X	-	-	-	-	-	X	-	-	C
<i>Cyclotella glomerata</i> Bachman	-	B	-	-	X	-	-	-	-	A
<i>Cyclotella meneghiniana</i> Kützing	X	X	C	-	X	A	B	-	-	-
<i>Cylindrotheca closterium</i> (Ehrenberg) Reiman et Lewin	X	X	-	X	C	X	X	-	X	B
<i>Cymbella</i> sp. #1	X	-	-	-	X	-	-	-	-	-
<i>Cymbella</i> sp. #2	-	X	-	-	-	-	-	-	-	-
<i>Diploneis crabro</i> Ehrenberg	-	X	-	-	-	-	-	-	-	-
<i>Ditylum brightwellii</i> (West) Grunow	-	X	X	-	-	-	-	-	-	-
<i>Eunotia praerupta</i> Ehrenberg	-	-	-	-	X	-	-	-	X	X
<i>Fragilaria</i> sp.	X	X	X	-	X	-	-	-	-	-
<i>Gyrosigma</i> sp.	X	-	-	-	-	-	-	-	-	-
<i>Gyrosigma balticum</i> (Ehrenberg) Cleve	-	-	-	-	X	-	-	-	-	-
<i>Gyrosigma wansbeckii</i> (Donkin) Cleve	X	-	-	X	-	-	-	-	-	-
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	-	-	-	X	-	-	-	-	-	-

Table 1. (continued)

	7 Oct 81	18 Oct	22 Nov	9 Mar 82	14 Apr	26 Jun	10 Jul	7 Aug	18 Sep	9 Oct
<i>Leptocylindrus danicus</i> Cleve	-	X	-	-	-	-	-	-	-	X
<i>Licmophora</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Licmophora paradoxa</i> (Lyngbye) Agardh	-	-	-	X	-	-	-	-	-	-
<i>Melosira distans</i> (Ehrenberg) Kützing	-	-	-	X	-	-	-	-	-	-
<i>Melosira moniliformis</i> (Muller) Agardh	X	-	-	-	X	-	-	-	-	-
<i>Melosira nummuloides</i> (Dillwyn) Agardh	-	-	-	-	-	-	-	-	-	X
<i>Navicula</i> sp. #1	X	-	-	-	X	X	-	-	X	X
<i>Navicula</i> sp. #2	X	X	X	C	X	-	X	-	-	-
<i>Navicula arvensis</i> Hustedt	-	C	-	X	-	-	X	-	-	-
<i>Navicula spicula</i> (Dickie) Clebe	-	-	-	A	-	-	-	-	-	-
<i>Nitzschia</i> sp.	X	X	X	X	-	-	-	-	X	-
<i>Nitzschia clausii</i> Hantzsch	X	-	-	-	X	-	-	-	-	-
<i>Nitzschia longissima</i> (Brébisson) Ralfs	C	B	X	-	-	X	X	X	X	-
<i>Nitzschia paradoxa</i> (Gmelin) Grun	-	X	-	-	-	-	-	-	-	-
<i>Nitzschia sigma</i> (Kützing) Smith	-	X	X	-	-	-	-	-	-	X
<i>Nitzschia vermicularis</i> (Kützing) Hantzsch	X	-	-	-	-	-	-	-	-	-
<i>Pinnularia</i> sp.	X	-	-	-	-	-	-	-	-	X
<i>Pinnularia major</i> (Kützing) Rabenhorst	X	-	-	-	-	-	-	-	-	-
<i>Plagiogramma</i> sp.	X	-	-	-	-	-	-	-	-	-
<i>Rhizosolenia alata</i> Brightwell	-	X	-	-	-	-	-	-	-	-
<i>Rhizosolenia delicatula</i> Cleve	-	X	-	-	-	-	-	-	-	-
<i>Skeletonema costatum</i> (Greville) Cleve	-	X	-	-	-	-	-	-	-	-
<i>Stenopterobia anceps</i> (Lewis) Brébisson	-	-	-	X	-	-	-	-	-	-
<i>Stephanopyxis palmeriana</i> (Greville) Grunow	-	X	-	-	-	-	-	-	-	-
<i>Surirella</i> sp.	-	-	-	-	-	X	-	-	-	-
<i>Surirella fastuosa</i> Ehrenberg	-	X	X	X	-	-	-	-	-	-
<i>Surirella striatula</i> Turpin	-	-	X	-	-	-	-	-	-	-
<i>Synedra</i> sp.	-	-	-	-	-	-	-	X	-	-
<i>Thalassionema nitzschioides</i> Hustedt	X	X	-	-	-	-	-	-	-	-
<i>Thalassiosira</i> sp.	-	-	X	-	-	-	-	-	-	-
<i>Tropedoneis lepidoptera</i> (Gregory) Cleve	X	X	X	-	X	X	X	-	X	X
Unidentified centrales	-	-	-	-	-	-	X	-	-	X
Unidentified pennales	X	X	-	-	X	X	-	-	X	X

CRYPTOPHYCEAE

<i>Chroomonas</i> sp.	X	X	-	-	-	-	-	-	-	-
<i>Chroomonas caroliniana</i> Campbell	A	-	-	-	-	-	A	X	X	X
<i>Cryptomonas</i> sp. #1	C	-	X	-	-	-	X	-	-	-
<i>Cryptomonas</i> sp. #2	-	-	-	-	-	-	-	X	-	-

CHLOROPHYCEAE

<i>Chlamydomonas</i> sp.	-	-	X	-	-	-	-	-	-	-
<i>Chlorella</i> sp.	X	X	-	-	-	-	X	X	X	X
<i>Chlorella vulgaris</i> Beyerinck	-	X	-	X	-	X	-	X	X	X
<i>Cladophora</i> sp.	X	-	-	-	-	-	C	X	A	-

Table 1. (continued)

	7 Oct 81	18 Oct	22 Nov	9 Mar 82	14 Apr	26 Jun	10 Jul	7 Aug	18 Sep	9 Oct
<i>Cladophora glomerata</i> Kützing	-	-	-	-	-	-	-	-	X	-
<i>Nannochloris atomus</i> Butcher	X	C	-	-	-	-	-	X	X	X
<i>Oedogonium</i> sp. #1	X	X	-	X	X	-	-	-	X	-
<i>Oedogonium</i> sp. #2	X	-	-	-	-	-	-	-	-	-
<i>Scenedesmus</i> sp. #1	-	-	X	-	X	-	-	-	-	-
<i>Scenedesmus</i> sp. #2	-	-	-	-	X	-	-	-	-	-

CHRYSTOPHYCEAE

<i>Chrysococcus minutus</i> (Fritsch) Nygaard	-	-	-	-	X	-	-	-	-	-
<i>Ochromonas</i> sp.	X	-	C	X	C	X	X	X	X	X
<i>Ochromonas miniscula</i> Conrad	X	X	-	-	-	-	-	-	-	-
<i>Ochromonas variabilis</i> Meyer	X	-	-	-	X	-	-	-	-	-

CYANOPHYCEAE

<i>Agmenellum quadriduplicatum</i> (Meneghini) Brebisson	-	-	X	-	-	-	-	-	-	-
<i>Anabaena confervoides</i> Reinsch	-	-	-	-	-	-	-	X	-	-
<i>Anabaena laxa</i> Rabenhorst	-	-	X	-	-	-	-	-	-	-
<i>Anacystis aeruginosa</i> Drouet et Daily	C	-	X	-	C	-	-	X	X	X
<i>Anacystis cyanea</i> (Kützing) Drouet et Daily	X	X	X	-	X	-	X	X	A	X
<i>Anacystis dimidiata</i> (Kützing) Drouet et Daily	X	X	-	-	-	-	-	-	X	X
<i>Anacystis marina</i> (Hansgrig) Drouet et Daily	X	X	-	-	-	-	X	X	X	X
<i>Aphanizomenon flos-aquae</i> (L.) Ralfs	-	-	-	-	-	-	-	-	X	-
<i>Calothrix aeruginosa</i> (Kützing) Thuret	-	-	-	-	-	-	-	-	X	-
<i>Coccochloris elabens</i> Drouet et Daily	-	-	-	-	X	-	-	-	-	-
<i>Gomphosphaeria aponina</i> Kützing	X	-	-	-	-	X	X	-	-	X
<i>Johannesbaptistia pellucida</i> (Dickie) Taylor et Drouet	X	X	-	C	X	-	X	-	-	X
<i>Lyngbya aestuarii</i> (Mert.) Liebmman	-	-	-	X	-	-	B	-	X	-
<i>Lyngbya confervoides</i> Agardh	X	X	-	-	-	-	-	-	-	-
<i>Lyngbya semiplena</i> Agardh	-	-	-	X	-	-	-	-	-	-
<i>Microcoleus vaginatus</i> (Vaucher) Gomont	-	X	X	-	-	-	-	-	-	-
<i>Nodularia</i> sp.	-	-	-	X	-	-	-	-	-	-
<i>Nodularia spumigena</i> Mertens	X	-	-	X	C	-	X	-	-	-
<i>Nostoc</i> sp.	X	-	-	-	-	-	-	-	-	-
<i>Nostoc commune</i> Vaucher	X	-	-	-	X	X	B	-	X	-
<i>Oscillatoria</i> sp. #1	X	X	-	X	X	-	-	-	-	X
<i>Oscillatoria</i> sp. #2	X	X	-	-	-	-	-	-	-	X
<i>Oscillatoria curviceps</i> Agardh	-	-	-	-	-	-	-	-	-	X
<i>Oscillatoria erythraea</i> (Ehrenberg) Kützing	-	X	-	-	-	-	-	-	-	-
<i>Oscillatoria ornata</i> Kützing	-	-	-	X	-	-	-	-	-	-
<i>Oscillatoria principes</i> Vaucher	-	-	-	-	-	-	-	-	X	C
<i>Oscillatoria submembranacea</i> Ardissonne et Strafforella	X	X	-	X	X	-	X	-	X	X



Table 1. (continued)

	7 Oct 81	18 Oct	22 Nov	9 Mar 82	14 Apr	26 Jun	10 Jul	7 Aug	18 Sep	9 Oct
<i>Tetraselmis maculata</i> (Kylin) Butcher	-	X	-	-	-	-	-	-	B	-
<i>Tetraselmis striata</i> Butcher	-	-	-	-	-	-	-	-	X	X
<u>XANTHOPHYCEAE</u>										
<i>Stipitococcus</i> sp.	-	X	-	-	-	-	-	-	-	-
<i>Tribonema</i> sp.	-	-	-	-	X	-	-	-	-	-
<i>Tribonema minus</i> (Willie) Hazen	-	-	-	-	-	-	-	-	X	-
<i>Tribonema angustissimum</i> Pascher	-	-	X	-	X	-	X	-	X	X
<i>Tribonema taeniatum</i> Pascher	-	-	-	-	X	-	-	-	-	-
Unidentified cells <3 µm	X	X	-	X	X	-	X	X	X	X
Unidentified cells 3-5 µm	X	-	-	X	-	X	X	X	-	X



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**Introduction of Anthribus nebulosus (Coleoptera:  
Anthribidae) in Virginia for Control of  
Scale Insects: A Review** [ ]

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ABSTRACT

A new biological control agent, Anthribus nebulosus Forster, was introduced from Hungary to Virginia during 1975 and 1977, successfully field-released in 1978, and established in the state by 1981. Methods of collection, introduction, rearing and release of the beetles are presented. A comparison was made of climatic conditions in its native habitat with that of the release site. Known distribution, life cycle, feeding habits, the scale insect prey, the natural enemies of A. nebulosus and other associated organisms are reviewed, as are reports on its effectiveness as a biological control agent in Europe. This was the first introduction of this beneficial beetle to North America. Anthribus nebulosus feeds on and destroys colonies of scale insects of about 15 species in Europe and Central Asia. Four of these scale insects are also pests in the Eastern United States. These include the European fruit lecanium, Parthenolecanium corni (Bouché); nut scale\*, Eulecanium tiliae (Lin.); and the small and the large spruce bud scale\*, Physokermes hemicryphus Dalman, P. piceae Schrank. Because the beetles feed on closely related scale insects in Europe, they have the potential to also control the cottony maple scale, P. innumerabilis (Rathvon); cottony peach scale, Pulvinaria amygdali Cockerell; cottony vine scale, P. vitis (Lin.); the European peach scale, Parthenolecanium persicae (Fabr.); Fletcher scale, P. fletcheri (Cockerell); oak lecanium, Parthenolecanium quercifex (Fitch), and terrapin scale, Mesolecanium nigrofasciatum (Pergande) in North America. They are known to destroy up to 90% of certain scale insects in their native land. Within three years after release, we have achieved over 30%

\*These are common names from European literature.

control at a release site in southwest Virginia. Beetles had dispersed as far as 13 km by Fall 1982.

### INTRODUCTION

There are a number of soft scales in the Eastern United States without effective natural control agents. Many of the same species are also pests in Europe, but their native biological control agents usually keep the pest populations under economic injury level. Anthrribus nebulosus Forster, is an effective predator for at least 15 species of scale insects in Europe and Central Asia (See Table 1). The beetle belongs to the family of fungus weevils, Anthribidae. The adults are somewhat robust, convex, and oval, about 2.0 - 4.0 mm long, and 1.5 - 2.0 mm wide, and grayish-black.

In 1975 work was initiated for the evaluation, collection in Europe, introduction to the United States, rearing and release of this new biological control agent. The following is a review of the available information on this insect and on our work completed between 1975 and 1982.

### DISTRIBUTION AND CLIMATIC FACTORS

Anthrribus nebulosus is considered an Euro-Siberian species with distribution in Central Palearctic, in areas of deciduous forests, spruce forests, orchards and on ornamental trees when these are infested with their prey scale insects. Prior to 1978, it was reported from the following countries: Bulgaria, Finland, France, Germany, Hungary, Poland, and USSR (Ukraine to Eastern Kazakhstan). It is more common in Central Europe than the related species, A. fasciatus Forster, which has a more southern distribution and was reported as far south as Italy by Silvestri (1919). Prell (1925) reported A. nebulosus to be more common in Germany than A. fasciatus.

Anthrribus nebulosus prefers the temperate continental climate with moderately low humidity and precipitation. To obtain some indication of their chances for survival in SW Virginia, we compared the temperature records for a six year period (July 1976 - June 1981) from their area of collection at Csopak, Hungary, (Fig. 1), with that of Blacksburg, Virginia (Fig. 2). The comparison shows similarities in monthly averages, but there are more frequent extremes in lower minimum and higher maximum temperatures in Hungary, when compared with the same monthly averages from Blacksburg. There was a higher amount of precipitation in Blacksburg (Fig. 3). The relative humidity was higher from April through September, and varied less in Blacksburg, while in Csopak, Hungary, the monthly relative humidity averages were higher from October through December (Fig. 3).

### LIFE CYCLE AND PREY SCALE INSECTS

The life cycle of the beetle is intimately related to the phenology of the host scale species. Anthrribus nebulosus and all 15 species of scale insects (Table 1) that serve as host for the beetle have one yearly generation in the areas studied.

Matesova (1966) studied the biology of Arthrribus nebulosus in the dry steppe regions of Eastern Kazakhstan (USSR). Illes et al (1896) in Hungary, and Goanca et al (1974) in Moldavia (USSR), studied the same beetles under the moderately dry continental climate of east central Europe. Schmutterer (1952) and Forster

Table 1. Known host scale insect species preyed on by *Anthrribus nebulosus* Forster

Species of Coccoidea	Known Areas of Predation*
Fam. Coccidae (soft scales)	
<i>Eulecanium caraganae</i> Borchsenius	USSR: Leningrad Region (3)
<i>Eulecanium ciliatum</i> (Douglas)	S. Germany (18,19)
<i>Eulecanium douglasi</i> Sulc	USSR: East Kazakhstan (14)
<i>Eulecanium sericeum</i> (Lindinger)	S. Germany, Poland (10,18)
<i>Eulecanium tiliae</i> (Lin.)	France, S. Germany, USSR: Leningrad Region, E. Kazakhstan (3,7,14,15,18,20)
<i>Nemolecanium abietis</i> Borchsenius	USSR: Ukraine (23)
<i>Parthenolecanium corni</i> (Bouché)	As above ( <i>E. tiliae</i> ), Hungary (3,7,9,14,18,20,23)
<i>Parthenolecanium rufulum</i> (Cockerell)	S. Germany (18,20)
<i>Physokermes hemicryphus</i> Dalman	Germany, USA: Virginia (since 1978)(5,7,11,19,20)
<i>Physokermes inopinatus</i> Danzig & Kozár	Hungary (12)
<i>Physokermes piceae</i> Schrank	Germany, USSR: Leningrad Region, E. Kazakhstan (3,5,11,14,19,20)
<i>Pulvinaria betulae</i> (Lin.)	USSR: Ukraine (23)
<i>Rhodococcus perornatus</i> (Ckll. & Parrott)	Bulgaria (24)
<i>Rhodococcus spireae</i> Borchsenius	USSR: E. Kazakhstan (14)
Fam. Kermesidae (gall-like scales)	
<i>Kermes quercus</i> (Lin.)	Germany (15)
Host scale undetermined, probably <i>Physokermes piceae</i>	Finland (17)

\*The numbers in parentheses correspond to articles listed in the References Cited.

FIG. 1. TEMPERATURE RECORDS FROM CSOPAK, HUNGARY  
DAILY MAX., AVE. AND MIN.

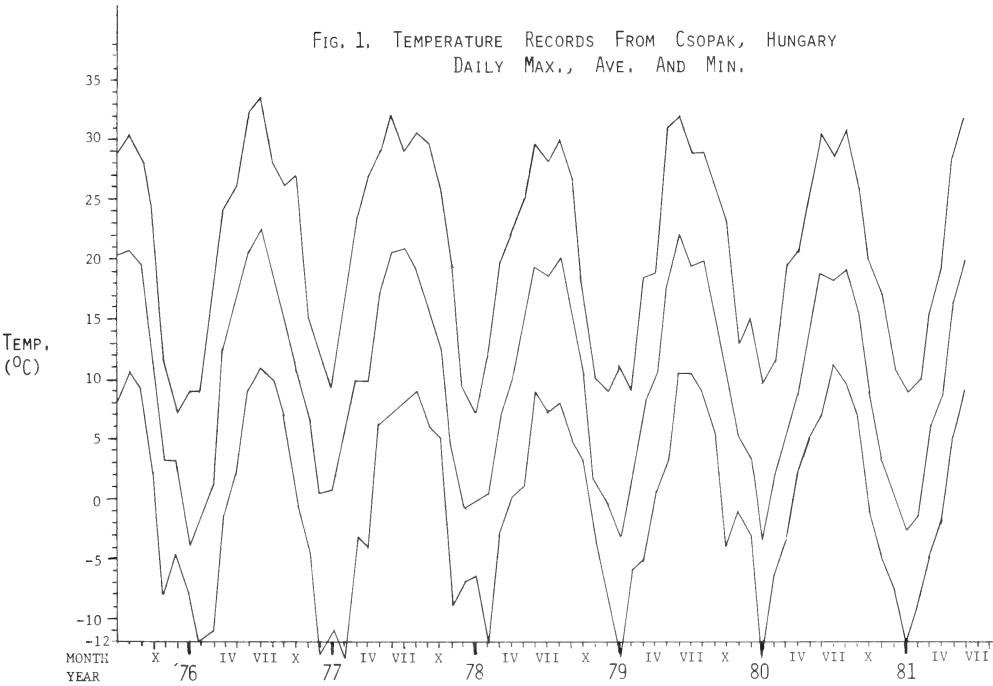


FIG. 2. TEMPERATURE RECORDS FROM BLACKSBURG, VA  
DAILY MAX., AVE. AND MIN.

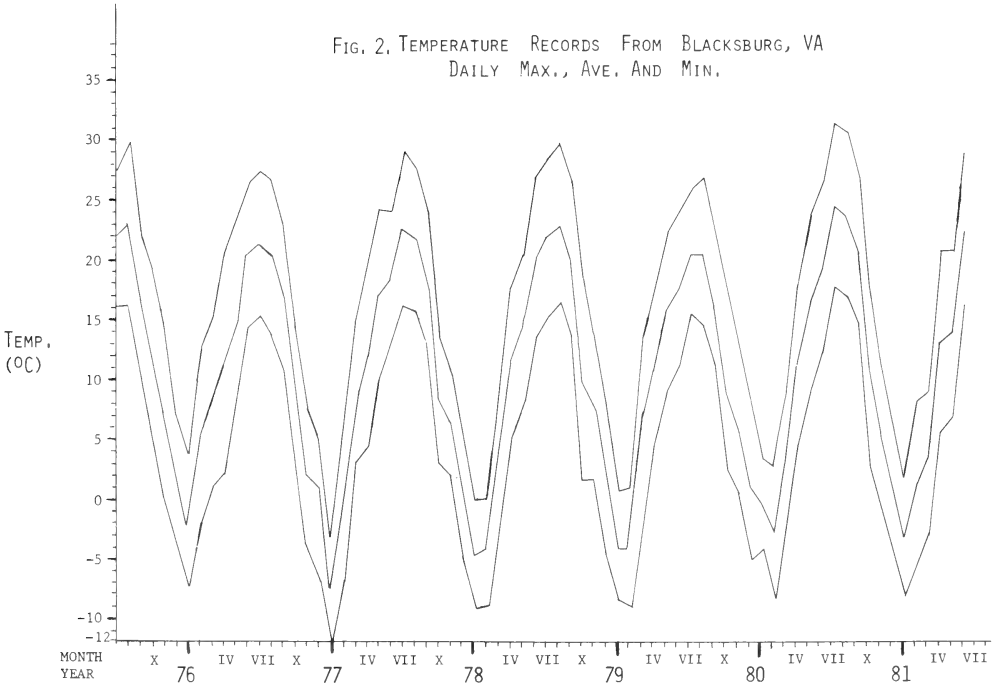
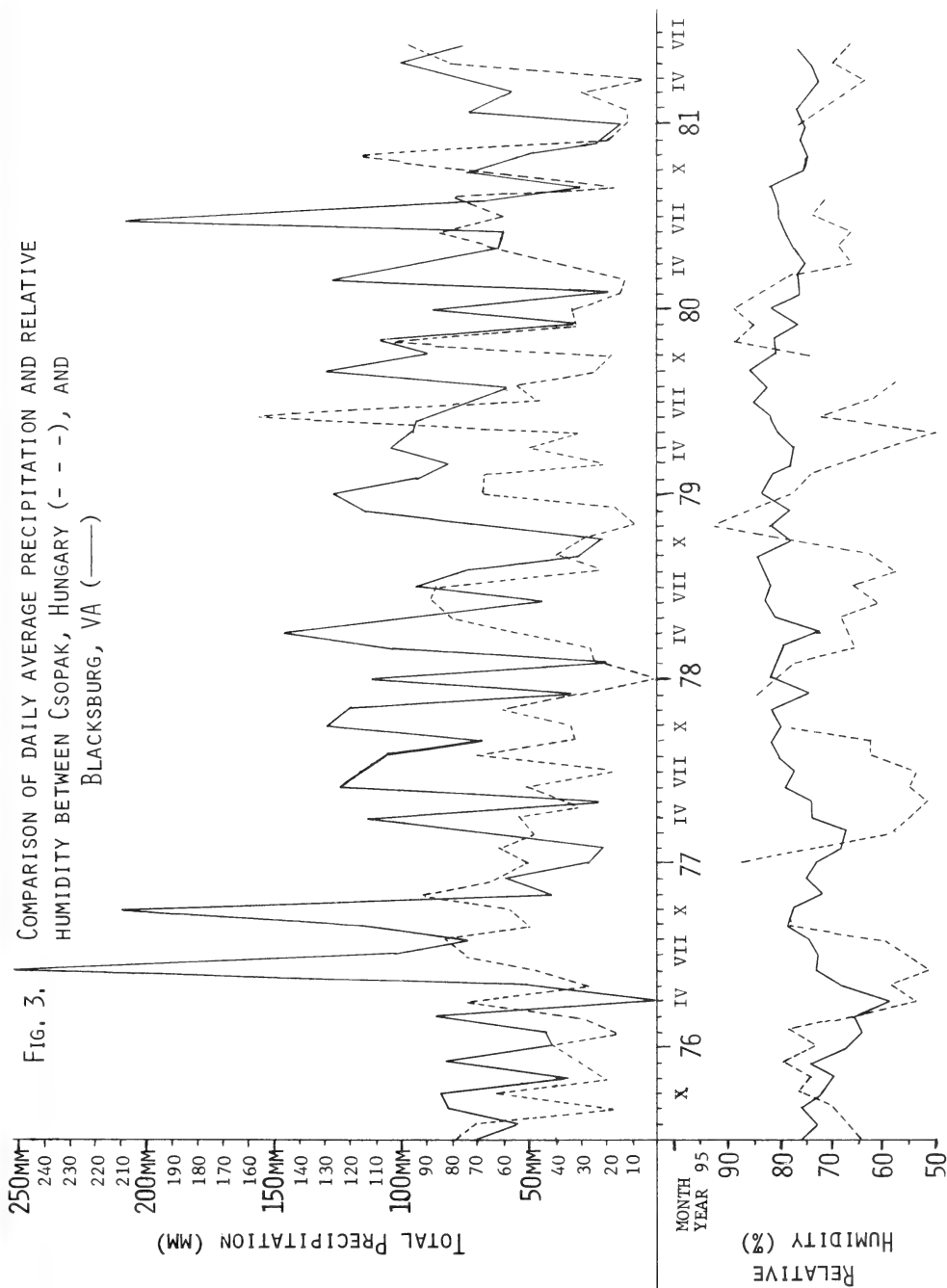


FIG. 3.  
COMPARISON OF DAILY AVERAGE PRECIPITATION AND RELATIVE  
HUMIDITY BETWEEN CSOPAK, HUNGARY (---), AND  
BLACKSBURG, VA (—)



(1973) studied them under the more humid conditions of west central Europe. Climatically, our area of release in southwest Virginia is closest to west central Europe. Our comments below are based on a synthesis of all these works plus our own. In both Moldavia and southwest Virginia overwintered adults appeared for the first time from mid-April; fed on scale honeydew, all stages of scale insects, and on fungi; laid eggs from early May through early June. These were deposited by chewing a hole on the still soft body side of the scale insect female and laying an egg in the brood chamber and by plugging the wound with their salivary secretion. These egg-laying sites later showed as dark spots on the hardened scale body. Egg laying of *A. nebulosus* was often successfully prevented by the attack of ants in Germany. The larvae developed and pupated under the scale exoskeletons from mid-June through July, the pupal period lasting from one to a few weeks; adults emerged by chewing a hole on the lateral side or on dorsum of the female scale exoskeleton; newly emerged adults fed on remains of old scale insect female exoskeletons ("mummies"), on scale insect honeydew and on remains of scale insect eggs in Europe and in Virginia. The beetles increased to high populations only during the year following the scale insect outbreaks in western Europe. This was also our own conclusion at Csopak (Fig. 4). The adult beetles went into diapause as early as August in S. Germany, and August and September in southwest Virginia. The diapause lasted until the following spring. The beetles chose leaf litter and crevices in the trunk and branches for overwintering in Moldavia (Goanca et al 1974), but in Finland and Germany (Schmutterer 1952, 1965; Forster 1973) each beetle chewed a small gallery in the bark and rested at its end. For shelter they used bark crevices and empty female scale insect exoskeletons in Germany (Forster 1973) and in southwest Virginia (Kosztarab & Rhoades 1983) and leaf litter and scale exoskeletons in Hungary (Illés et al 1896). The available literature agrees that larvae feed individually or rarely in groups of 2 or 3 under each egg laying scale insect female, and devour the eggs as they are being laid.

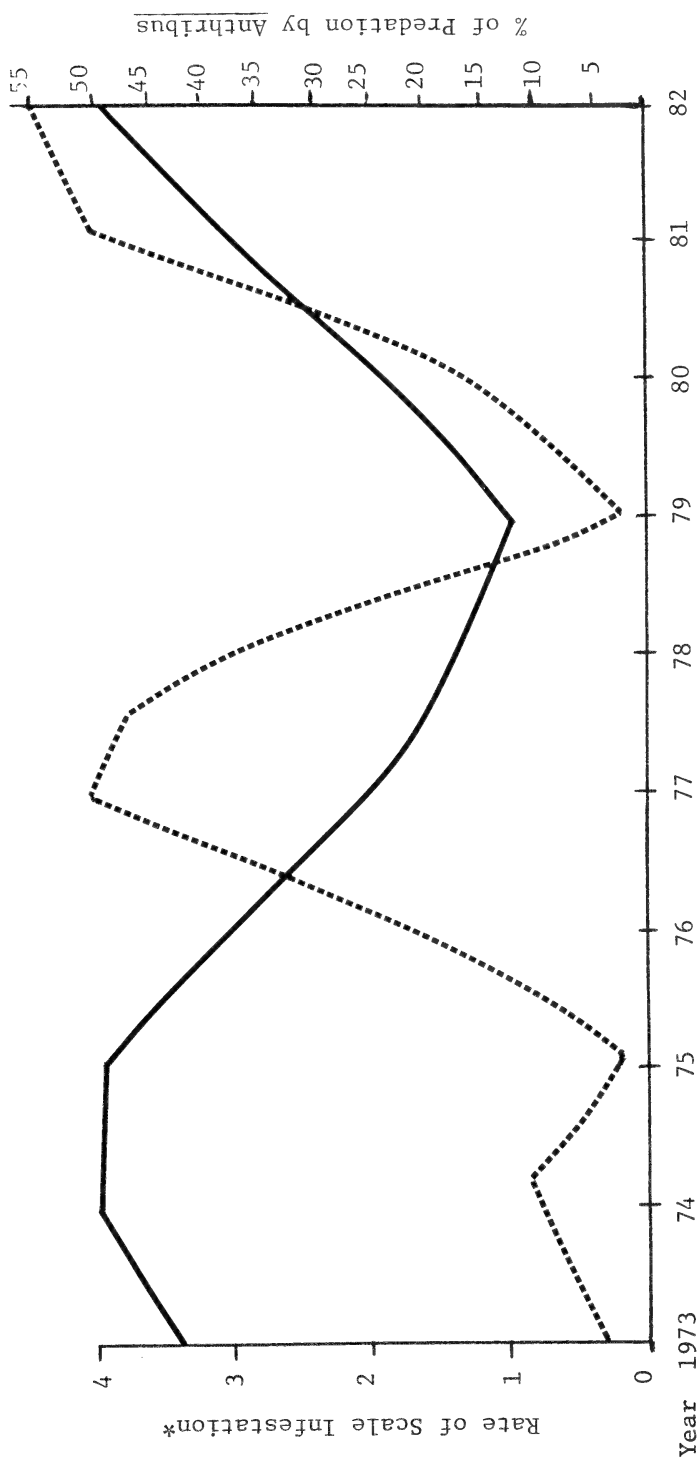
#### NATURAL ENEMIES OF *ANTHRIBUS NEBULOSUS* AND SOME ASSOCIATED ORGANISMS

Among the natural enemies of adult beetles in Central Europe, Csiki (1906) listed five species of titmice: *Parus ater* Lin., *P. coeruleus* Lin., *P. major* Lin., *P. palustris* Lin., and *Aegithalus caudatus* Lin. Stomach content studies of these birds proved that they fed on beetles from October through February (1901-1904). There were 4 to 28 beetles per bird stomach during March-April and during August-September. This number increased to between 6 and 50 in December. During December a total of 267 beetles occurred in 9 titmouse stomachs. It was assumed by Csiki that, because of snow cover in December, the birds were forced to feed in the tree crowns where they found overwintering beetles inside shelters provided by bark crevices and the dead scale insect exoskeletons. The snow cover is normally thicker and lasts longer in Hungary than in the Mid-Atlantic states. This is why we believe that birds will not significantly affect the beetle populations in the area of our releases.

Organisms found on the host trees, Norway spruce, (*Picea abies* (L.) Karst), associated with *A. nebulosus* at the collecting site in Csopak, Hungary, between 1975 and 1981 were:

Dermoptera: Forficulidae: *Forficula auricularia* Lin., European Earwig. Since its population size followed the scale population increase it is probably a predator of the scale host.

Fig. 4. Ten Year Population Fluctuation of Scale Host, *Physokermes inopinatus* (solid line) and Predation Rate by *Anthribus nebulosus* (dash line) at Csopak Hungary.



\*Rate of scale infestation is given in a scale of 0 to 4, after Borchsenius (1950) as follows: 0=scales absent; 1=only few single individuals present; 2=scales form small colonies of 2 to 10; 3=scales form large colonies of 11-100; 4=plants generally infested.

Hemiptera: Lygaeidae: Gastrodes grossipes (DeGeer). It is known only from bark and cones of conifers.

Neuroptera: Chrysopidae: Chrysopa perla Lin. Larvae are predators on a variety of insects.

Coleoptera: Coccinellidae: Adalia bipunctata (Lin.), Coccinella septempunctata Lin., Exochomus quadripustulatus (Lin.) and Scymnus (Pullus) impexus Mulsant. All four lady beetles are known predators of scale insects.

Bruchidae: Bruchidius nudus Allard. This seed weevil is known from Cytisus triflorus L'Herit (Leguminosae) only.

Hymenoptera: Eurytomidae: Eurytoma sp. was found as an external parasite of beetle pupae in the material collected by the authors at Csopak, Hungary, during June 1981.

In addition, honeydew collecting ants in the genera Camponotus and Formica, also members of the species and ants Lasius niger Lin., L. alienus Forster attacked the beetles and often successfully prevented their egg laying on host scale insects (Schmutterer 1952, 1965).

#### PROCEDURE FOR INTRODUCTION TO VIRGINIA

Collecting in Europe: The adult beetles have been collected each year (except in 1976) since 1975 at Csopak, Hungary, from Norway spruce trees that were infested with Physokermes inopinatus scale insects. The trees were 18-26 years old, with an average height of 8 m. Usually 12 to 16 of the most heavily infested trees were selected for collecting. Best results were obtained during sunny days without wind, around 24°C, between 11 AM and 2 PM, from end of June through early July.

White cloths were placed on the ground under the tree and the branches starting from the top were vigorously beaten and shaken with a long handled garden tool to dislodge the beetles into the cloths. Contents from the cloths were shaken into a wide mouth glass jar and/or into a large plastic bag when it contained too much residue from the tree. Because most of the beetles hold on to the cloths, most of the tree residue could be easily separated from the beetles with light shaking of the cloths. Only very few beetles flew away. The collected and separated beetles were supplied with fresh branches of spruce with live scale first instars, adult female scale exoskeletons, and with water in cotton stoppered vials. Each tree provided from 18 to 90 beetles in 1981.

The tree residue that was collected in large transparent plastic bags contained small broken twigs, needles, scale insect exoskeletons that often included live adult beetles or their pupae, different parasites and predators of the beetles and/or of their host scale insect, and other associated organisms. This residue provided many additional beetles when the plastic bag containing the residue was placed in the sun with its closed top directed up. The plastic bag was utilized as a sun-heated inverted Berlese funnel. The beetles and some other live arthropods, due to the heating of the contents of the plastic bag by the sun, aggregated on top, near the closed top of the bag, where they were collected at regular intervals. It was practical to check these bags during the day from 10 AM to 4 PM every half an hour. We removed the beetles and other organisms from the top and transferred them into rearing containers. A 700 gr residue





**Fig. 5**

**Plastic box with screened top and corrugated paper rolls used for shipping beetles to the United States; also used for overwintering.**

sample provided 206 beetles from 10 to 4 PM on July 10, 1981 (first day after field collecting).

Shipping. Beetles were kept with food (live and dead scale insects, sooty mold fungi on needles) and water in wide mouthed rearing jars (2 l.) covered with cheese cloth, until ready for shipping. Rolls (4 to 6) of corrugated paper (as in Fig. 5) were included in each jar for shelter. About 80% of beetles displayed positive thigmotaxis, by moving into the grooves of the corrugated paper rolls, and a few inside exoskeletons of scale insects. They became motionless in these shelters and went into summer diapause.

Just before shipping, the beetles were transferred into rigid plastic containers (25 X 17.5 X 6 cm) with screened tops for ventilation (Fig. 5). The copper screen had 600  $\mu$  square mesh openings to prevent escape. The water vials were attached to the bottom of the container to avoid rolling while in transport. The plastic containers with the beetles were brought with personal luggage on regular aircraft to the United States.

Rearing. After arrival in Blacksburg, Virginia, the beetles were transferred into cages with wood frames and organdy walls, a bottom of 1/2" plywood and a sliding door of thick window glass. The beetles were provided with shelter of corrugated paper rolls, and for food with dead adult females and live nymphs of Parthenolecanium quercifex and Physokermes hemicryphus. The scales were on twigs with leaves of pin oak, Quercus palustris Muenchh., or needles of Norway spruce placed in water-filled 250 ml. beakers with cotton plugs. Water was provided in cotton stoppered vials. The food sources and water were replenished as needed once or twice weekly. The beetles were kept under observation for possible parasitization and for pathogens carried

with them from the country of origin. Only in one case did we find a parasitic hymenopteran in Hungary before shipping. After feeding and drinking, many of the beetles retreated into the shelters for summer diapause that often continued without interruption into winter diapause. During November, the corrugated paper roll shelters with the beetles were transferred for overwintering into securely locked double cages.

Overwintering. Food and additional shelters were provided with the inclusion of scale insect exoskeletons, in the overwintering boxes, a 5 or 10% sugar solution, and tap water, which were added in cotton or sponge stoppered vials. For overwintering we used the same plastic boxes with screen tops (Fig. 5) that were used earlier for their transportation. The box was placed in a 28 l. plastic trash can filled with dry oak leaves and securely covered with organdy. The plastic can was placed in the closed rearing cage, provided with a polyethylene roof, and the latter in a large locked, screen walled cage. We found the overwintering mortality to be 32-67% when the beetles were overwintered under outdoor conditions in Blacksburg during 1977 and 1981. Our earlier attempts during the winter of 1975-76 to keep the overwintering beetles inside growth chambers, simulating outdoor winter conditions, were not successful. In this experiment the beetles were kept inside wide mouth 3 l. jars covered with cheese cloth and were provided with honey-water, and distilled water in cotton stoppered vials, spruce shoots with P. hemicryphus, and oak shoots with Kermes kingi Cockerell nymphs and dead adults. Water and food were checked and replenished weekly as needed. Day-night photophases were synchronized with the shorter day length during the winter months, simulating the outdoor conditions.

During the first week of April, the overwintered beetles were transferred into rearing cages (described earlier) and kept inside the laboratory, where potted oaks infested with Kermes kingi and Parthenolecanium quercifex provided food and egg laying sites for the beetles.

Establishment in Virginia. After three years (1975-1978) of rearing experiments, the progeny of our 1977 introduction (ca 150 beetles) were field released during October 1978 in Blacksburg, SW Virginia (VPI & SU campus), on Norway spruce trees infested with Physokermes hemicryphus live nymphs and dead adult female exoskeletons. The beetles were individually placed with camel's hair brush on twigs infested with this scale insect. The procedure was repeated with ca 200 more beetles on the same trees during September 1979.

Monitoring of Released Populations. Scale insect exoskeleton samples were taken and the trees checked three times yearly, starting during the spring of 1979, and continuing each summer, fall and spring through 1982. The predation rate reached 30.1% by August 1981 (Fig. 6). After 1980, we started checking the surrounding area for evidence of beetle dispersal. The beetles were recaptured in Blacksburg, at about 1 km east of the original release site during Fall 1981 and Spring 1982. During the Fall 1982 a few beetles were captured on trees at about 13 km direct line distance southwest (Radford University) of the release site. At each location the beetles fed on P. hemicryphus present on Norway spruce trees.

To provide evidence of dispersal and predation, we utilized a light colored vinyl-nylon tarpaulin of about 4 X 5 m. size. The tarpaulin was placed on the ground before vigorously shaking

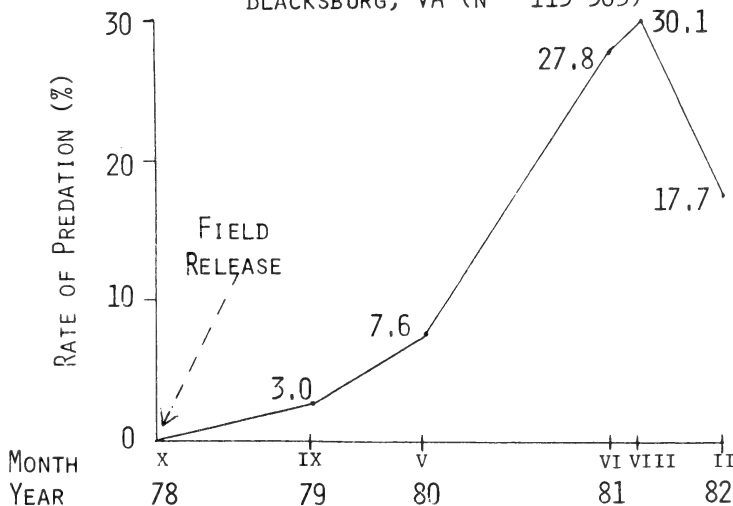
the spruce branches. The fallen residue was hurriedly shaken into plastic bags to prevent escape of beetles, and it was checked in our laboratory under a dissecting microscope for beetles and/or evidence of predation (emergence holes on the collected scale insect exoskeletons). This procedure was repeated during the months of April, June or July and September. In addition to the large ragged beetle emergence holes, we found large numbers of small circular chalcid parasite emergence holes. Field Release at Virginia Beach. During Fall 1981, we field-released about 300 more beetles at a new site at Virginia Beach on pin oak trees infested with oak lecanium, *P. quercifex* (Schultz 1981). Our Spring 1982 recapture samples did not provide evidence of their survival and/or establishment in Eastern Virginia. Due to budgetary limitations, we had to temporarily discontinue further biological control work in that area.

#### RATE OF PREDATION BY *ANTHRIBUS NEBULOSUS*

Geza Horvath, as given in Illes et al (1896) reported from Hungary that among the three most effective natural enemies of the brown scale, *Parthenolecanium corni*, in black locust forests, (*Anthribus nebulosus*, the chalcid, *Coccophagus scutellaris* Nees, and the lady beetle, *Exochomus quadripustulatus* Lin.), *A. nebulosus* (=various) was the most effective. It was so well established in certain areas in 1890, that the reduction of scale populations was remarkable.

*Anthribus nebulosus* was found by Dyadechko (1954) to significantly reduce the number of soft scales on oaks in the forests of the Ukraine. A similar observation was made by Matesova (1966) in the forests and steppe zones of Eastern Kazakhstan, and by Danzig (1959) in the Leningrad Region. The latter author noted that ca 30% of *Eulecanium caraganae* eggs, and ca 50% of *Parthenolecanium corni* eggs were destroyed by the larvae of this beetle.

FIG. 6. PREDATION OF *ANTHRIBUS NEBULOSUS* FORST BEETLES ON *PHYSOKERMES HEMICRYPHUS* DALMAN, BLACKSBURG, VA (N = 113-365)



Klausnitzer and Forster (1976) found A. nebulosus to be the dominant natural enemy of large spruce bud scales, Physokermes piceae, in the Dresden area, Germany, and it was responsible in 1971 for 58.6%, and in 1972 for 37.9% of the scale insects destroyed. Schmutterer (1965) also reported A. nebulosus as often destroying 90% of P. piceae colonies in Germany.

Predation by this beetle on Norway spruce infesting Physokermes inopinatus at Csopak, Hungary, from 1973, through 1982 ranged from 3 to 55% (Fig. 4). Three years following release, the beetles on our observation trees in Blacksburg, Virginia (Fig. 6), destroyed 30.1% of the Norway spruce infesting Physokermes hemicyphus.

#### NEEDED FUTURE WORK AND PLANS

Future studies on this species should include an investigation into economical mass rearing methods and a determination of its ecological requirements, including optimal indoor overwintering conditions. After a suitable host infestation is found, the beetles should be released in the Central States, eg. Kansas and Oklahoma, where the climatic conditions are similar to its natural range in Europe and Central Asia.

Multiple introduction of foreign parasites and predators of pest scale insects was strongly recommended by Rosen (1973) on both theoretical and practical grounds. New release attempts in the Norfolk area of Virginia where a number of nurseries occur might help to control oak lecaniums and other scales causing heavy damage on oaks and other ornamental and shade trees. New introductions, and further rearings are planned at VPI & SU, and as soon as funds are made available, the beetles will be released in other parts of Virginia, especially in the major fruit growing areas, such as the Shenandoah Valley.

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Hogge of Chesapeake, Virginia; and four *Ilex* sp. plants were also given by Dr. E. A. Borchers, Director of VTORS.

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**Food Consumption, Mating Behavior, and Shelter  
Selection of *Anthribus nebulosus* Forster  
(Coleoptera: Anthribidae), an Introduced Predator  
of Scale Insects in Virginia** CJ

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ABSTRACT

*Anthribus nebulosus* Forster adult beetles, whose larvae are predators of scale insect eggs, were observed in the laboratory from late July to mid-November and again after overwintering from mid-April to mid-August to study their feeding habits, shelter preferences, and mating behavior. Natural honeydew from 5 species of scale insects, artificial honeydew, sugar-water solution, water and sooty mold on twigs and leaves were consumed. All stages of live scale insects were eaten by beetles in the spring, but not in the fall. Dry exoskeletons of old female scale insects were used as food both times of the year. Response to shelters, which was studied only in the fall, was variable; 25% of the beetles eventually entered a shelter and stayed there. Old female scale insect exoskeletons were preferred by the beetles to black paper shelters. The average weight of a sample of beetles in mid-November was 3.6 mg. Length of 20 beetles averaged 4.0 mm (range 3.0-4.8), and width 1.7 mm (range 1.2-2.1).

Mating was recorded from April 14 to May 3, with copulation lasting 3 to 35 minutes. The preoviposition period after mating was 1-2 weeks, and the egg incubation period about 4 days. The combined larval and pupal stages lasted about 4 weeks. Adult longevity, after overwintering, ranged from 2 weeks to 4 months with males living as long as females.

INTRODUCTION

*Anthribus nebulosus* (Fig. 1) is an important predator of soft scale insects in Eurasia (Kosztarab & Kozár, 1983). Some of its prey scale insects (Family Coccidae) are also pests in North America, such as the European fruit lecanium, *Parthenolecanium corni* (Bouché); the nut scale\*, *Eulecanium tiliae* (Linn.); and the small spruce scale\*, *Physokermes hemicryphus* (Dalman). But

\*European common English names were used for these species because there are no approved common names in North America.

some of their Eurasian predators are absent from the American fauna. Although the first author released A. nebulosus in Virginia in 1978 and they have become established in low numbers in three localities in southwest Virginia, little was known about their biology except the general life cycle (Kosztarab & Kozár 1983). Matesova (1966) stated that there is only very limited information on its biology. Our search for literature on this species provided about 26 articles, but most of these gave little useful information, and what was available was often contradictory. Our objectives with these laboratory studies were to find out their feeding habits, shelter preferences, mating behavior and development.

#### MATERIALS AND METHODS

##### Fall Observations

Adult beetles were collected at Csopak, Hungary, on July 8, 1981, from Norway spruce trees Picea abies (L.) Karst, infested with Physokermes inopinatus Danzig and Kozár and maintained in the VPI&SU Beneficial Insect Introduction Laboratory until their use for these tests. All laboratory observations were made at 17-33°C, relative humidity 30-90%. One or more beetles were placed in plastic or glass petri dishes with the various materials to be tested for their attractiveness to the beetles (Fig. 2), and observed for several weeks. Two sizes of dishes were used, 9 cm wide x 1.9 cm deep for tests with one or two beetles, and 14 cm wide x 1.9 cm deep for tests with five beetles. A disc of white filter paper covered the bottom of each dish to add traction for the beetles. A 3 ml glass vial, filled with distilled water and stoppered with cotton was placed in each dish to provide free moisture. To distinguish individual beetles we painted a dot on their dorsum with white paper correction fluid.

The first tests were initiated on July 22 and continued for three months. Five times daily, every two hours, dishes were checked and the position and activity of each beetle noted. After two months, only daily observations were made. Some additional tests were started later and these were continued for two weeks to two months.

Shelter Selection. Both black and white paper shelters were provided to find out which the beetles preferred. These were made by rolling a 8 cm x 6 cm piece of construction paper into a tube starting at the shorter side and then bending one end back about 1 cm and making a tight crease (Fig. 2).

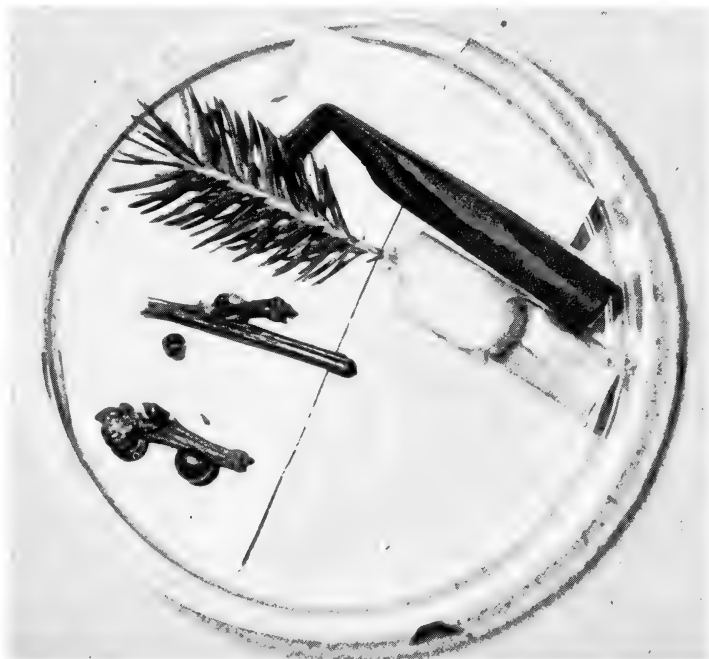
Different species of scale insects belonging to two families and four genera were tested for shelters also, so a choice of a natural shelter (an old female scale exoskeleton) or an artificial shelter (paper) was possible. Because of the time of year, only empty old female exoskeletons of P. hemicyphus were available. Fresh specimens, both prereproductive and postreproductive of Kermes kingi Cockerell (Kermesidae), an oak infesting gall-like scale insect; Toumeyella liriodendri (Cmelin) or tulip tree scale (Coccidae); and Ceroplastes ceriferus (Fabricius) or Indian wax scale (Coccidae), still attached to 3 or 4 cm long twigs, were placed in various dishes. The twigs on which these were found were kept fresh by immersing their lower part in 3 ml glass vials filled with distilled water and stoppered with cotton.





**Fig. 1**

*A. nebulosus* on Norway spruce, *Picea abies* twig, a common resting and grooming site.



**Fig. 2**

Example of petri dish used to observe *A. nebulosus* in the laboratory with black and white paper shelters, spruce twig in water vial, oak twigs, *Quercus rubra*, with *Kermes kingi* scale insects and empty *Physokermes hemicryphus* exoskeleton lying on filter paper.

Food Consumption. Food made available to the beetles included scale insect adults, nymphs, and eggs; honeydew produced by scales; artificial honeydew; sugar-water and some sooty mold fungi on twigs and leaves.

Kermes kingi, T. liriodendri and C. ceriferus produced eggs and nymphs while in the dishes with the beetles. An infestation of Planococcus citri (Risso), the citrus mealybug, on Begonia leaves provided all stages of this scale insect also. Because P. hemicryphus adults were dead, nymphs were collected nearby and introduced attached to spruce needles.

Honeydew was produced by the Kermes, Toumeyella and Planococcus. Two artificial honeydew solutions, one with a concentration of .025% by weight and the other at .05% were prepared using the following amino acids: lysine, glutamic acid, aspartic acid, alanine, valine, arginine, glycine, isoleucine, proline, threonine and tyrosine. To each solution a mold inhibitor (supplied by Carolina Biological Supply Co. for Drosophila medium) was added at .025% concentration. Sugar (sucrose) was added using 5% and 10% concentrations for the two solutions. A plain 10% sucrose solution was also made available to the beetles in one dish.

Sooty mold fungi were present in two tests. The first was a very dense natural fungal growth on a 6 cm section of a tulip tree twig (Liriodendron tulipifera L.), which had a lot of dried-up honeydew on it from the T. liriodendri scale insects infesting it. The second was a flat encrustation of sooty mold on oak and Camellia leaves. Identification of the fungi showed Cladosporium sp. to be present in all samples. Other fungi found associated were Alternaria sp., Aureobasidium sp., Bispora sp., Diplococcium sp., Fusicladium sp., Helminthosporium sp., and Spilocaea sp.

Twigs of Norway spruce, red oak (Quercus rubra L.), and tulip tree, which could be present in the beetles' natural environment, were introduced into the dishes with the beetles to see how they would react to them. Spruce twigs had no scale insects on them. All oak twigs had leaves removed and had one or more Kermes adult females attached. The tulip tree twig was covered with sooty mold fungi and had Toumeyella scales on it as described above.

Weight, Size and Sex Determination. To find the average weight of the beetles, 74 were weighed all together on a Mettler balance (accuracy to 0.1 mg.). Then the 10 specimens appearing largest and the 10 smallest were weighed individually to find the range. Length and width were measured with an Olympus binocular dissecting microscope and a slide calibrated to 0.1 mm. After measurements, they were killed in Weaver's Formol Fixative: 40% formaldehyde, 5 ml; glacial acetic acid, 2.5 ml; chloral hydrate, 20 g; distilled water to 100 ml. Dissections were made to determine their sex.

### Spring Observations

Eighteen beetles were removed from their outdoor overwintering cage on April 3, 1982, and brought indoors for observation. They were kept in the refrigerator at 3°C until April 11 and placed in four 14 x 1.9 cm plastic petri dishes each containing 4 or 5 beetles. A dot of "Liquid Paper" was painted on their dorsum so each could be identified individually. When 2 beetles died and 4 had escaped, the remaining 12 insects were placed in new dishes. Four beetles, known to be mated females

from observing copulations, were transferred to separate plastic petri dishes to observe egg laying habits. The other eight beetles were divided equally between two dishes.

Food was supplied to the beetles as in the fall study. Scale insects used in the spring were: *Parthenolecanium quercifex* (Fitch) on *Quercus phellos* L. twigs, *Physokermes hemicyphus* Dalman on *Picea abies* (L.) Karst. twigs, *Coccus hesperidum* L. on cyclamen leaves (all Coccidae); *Kermes kingi* Cockerell (Kermesidae) on *Q. rubra* L. twigs. Honeydew produced by these scale insects and sooty mold fungi (containing *Cladosporium* sp.), growing on the twigs and leaves were available as food. The same type of water vial used before was provided also. No paper shelters were put in the dishes.

Observations were made 4 times daily using a dissecting microscope. Hygrothermograph records showed the temperature in the laboratory varied from 17° to 33°C ( $\bar{X}$  = 19.5°C), and the relative humidity from 30 to 90% ( $\bar{X}$  = 54%).

## RESULTS AND DISCUSSION

Table 1 summarizes the fall activities of 18 *Anthribus nebulosus* adults from eight petri dishes. Since no difference in activities was found when more than one beetle was put in each dish, results are expressed for all the beetles collectively.

The last category in the table, labelled "Not Visible", includes three separate conditions. Sometimes even a thorough search did not reveal the beetle. Also, if the beetle was inside a paper shelter, it could not be seen unless the paper was unrolled, which meant disturbing the beetle, therefore shelters were not opened at every observation. The third circumstance was when a beetle escaped.

General Activity. Most beetles spent about 6% of their time moving around the dish, sometimes walking very rapidly, approximately the same amount of time they spent resting (Table 1). This latter category included only observations of beetles resting in the open. When they were holding still on a twig or on the water vial, etc., this was recorded elsewhere.

Beetles were found on their backs kicking about 4% of the time. This usually was the result of their falling off the lid and landing on the bottom of the dish where the smooth surface of the glass made it difficult for them to turn over. Covering the bottom of the petri dishes with filter paper helped alleviate this problem.

When beetles were found lying still on their sides or backs, they were usually moribund. The average for this category was about 7% of the observations (Table 1), although there was a wide range among the beetles.

Shelter Selection. Beetles showed a wide range of responses to the shelters provided, from some never entering a shelter to one going in August 5 and staying until mid-November when the experiments were terminated. The latter probably continued summer diapause into winter diapause, but most beetles moved in and out of the shelters rather than staying inside.

A definite preference was noted for black paper shelters over white ones (Table 1), so only black shelters were used in later experiments. Beetles moved in and out of the black shelters more often in late summer and tended to spend more time

Table 1. Activities of Anthribus nebulosus beetles in the fall as % of observations for each activity (N = 18 beetles).

Type of Activity	Mean	Range
<u>In the open space:</u>		
moving around dish	5.6	3.8 - 9.5
resting on legs	5.7	0 - 11.3
on back, kicking	3.7	0.4 - 17.0
lying on side or back	7.5	0 - 41.5
<u>Inside shelter:</u>		
white	0.6	0 - 1.8
black	21.4	0 - 47
<u>Drinking:</u>		
water	0.9	0 - 3.8
artificial honeydew (5% sugar)	3.5	0 - 9.5
<u>By <u>Physokermes</u> <u>exoskeleton</u>:</u>		
on top	0.08	0 - 1.0
inside (for shelter)	6.3	0 - 79
chewing on	0.02	0 - 0.4
<u>On spruce:</u>		
on twig	12.7	6.6 - 25
on wet cotton stopper	0.5	0 - 4
<u>On oak:</u>		
on twig	19.8	0 - 30.6
on wet cotton stopper	0.72	0 - 2.5
feeding on <u>Kermes</u>	1.5	0 - 4.4
moving <u>Kermes</u> egg	0.12	0 - 1.6
at or on <u>Kermes</u>	8.1	0 - 18.2
partly inside <u>Kermes</u>	0.54	0 - 4.3
entirely inside (for shelter)	3.3	0 - 39.9
at honeydew drop	1.2	0 - 9.1
chewing sooty mold	0.06	0 - 1.1
<u>Not visible:</u>		
(probably in shelter)	7.2	0 - 20.5

inside in the fall. Time inside a shelter ranged from 2 hours to 1-1/2 months.

The beetles did not use the Physokermes exoskeletons for shelters as much as the black paper ones (Table 1); only five beetles used these at one time or another. Time inside Physokermes exoskeletons ranged from two hours to a few days, except for one beetle which used an old exoskeleton for a permanent shelter.

Old Toumeyella females were made available to beetles in a separate test along with Physokermes and Kermes exoskeletons. Of five beetles, two chewed holes in the exoskeleton of a postreproductive Toumeyella female and one eventually went inside and stayed 18 days (until the experiment was terminated).

As with the other shelters, the beetles showed no distinct patterns in the use of the post-reproductive Kermes females. Eight beetles went inside for varying lengths of time, and three remained inside, with two beetles sharing the same shelter in one case for 21 days. Length of time spent inside Kermes exoskeletons ranged from two hours to one month.

Apparently the wax present on the live Ceroplastes females kept the beetles from chewing on this scale, as none were seen attempting to make a hole in any of these scales. This is an important finding that might prevent successful utilization of the beetles against wax scales in the Eastern United States.

Eight of the 31 beetles eventually sought permanent shelter, i.e. they went in and were not seen outside again. The time of entry ranged from August 5 to October 28. Five of these chose a female scale body for their permanent shelter and three chose a black paper shelter. Of the three latter, however, two had no other choice because only Ceroplastes scales were present and these were covered with wax. In one case a beetle chose a Kermes which was already occupied by another beetle. In four of the five cases where female scale bodies were used for shelter, beetles had to chew a hole in the female's exoskeleton to enter it. Jablonowski (1916) reported that the adult beetles stayed under the exoskeletons of Parthenolecanium corni (Bouché) for overwintering in Hungary.

Food Consumption in the Fall. Naturally produced honeydew was consumed by the beetles no matter which species of scale insect was the source, although not every beetle was observed feeding on it (Table 2). Beetles fed on both fresh and dried-up honeydew. Artificial honeydew was also ingested and the solution with the higher sugar content (10%) was preferred (Table 2). When a 10% sucrose-distilled water solution was introduced into a dish simultaneously with the 10% sucrose-amino acid solution, beetles showed no preference (Table 2). The beetles in this dish were never actually seen drinking natural honeydew, although they did spend a lot of time on the Begonia leaf which had honeydew from the mealybugs (P. citri). We are assuming that they were attracted to the Begonia leaf, not only as a shelter, but also as a source of honeydew.

Although first instars of Kermes, Toumeyella, and Physokermes (dead and alive) were present with the beetles for about two weeks, no interest was shown in them by the beetles. Even though first instars crawled over the beetles, including their antennae, the beetles did not respond. No feeding on live scale insect adults was seen either. Beetles did chew on old dry exoskeletons of Physokermes and Kermes, and on shriveled up

Table 2. Food consumption of Anthribus nebulosus in the fall.

Type of Food	Mean % of Observations	Range (%)
Natural honeydew:		
<u>Toumeyella liriodendri</u>	0.38	0 - 1.9
<u>Kermes kingi</u>	0.82	0 - 9.1
<u>Planococcus citri</u> *	8.9	0 - 27.4
Artificial honeydew (with amino acids):		
5% sugar	2.9	0 - 9.5
10% sugar	4.8	0 - 10.7
Sugar water (10%)	4.8	0 - 10.7
Sooty mold fungi:		
on oak	0.04	0 - 1.1
on tulip tree	5.3	0 - 15.8
Dry exoskeletons of postreproductive female scale insects:		
<u>P. hemicyphus</u>	0.02	0 - 0.4
<u>K. kingi</u>	1.3	0 - 4.4
<u>T. liriodendri</u>	2.3	0 - 7.7
<u>C. ceriferus</u> (without wax cover)	4.4	0 - 9.1

\*Not always actually eating the honeydew during observation.

Ceroplastes and Toumeyella exoskeletons which had a lot of dried up honeydew on them (Table 2). Eggs were moved by beetles when making a shelter, but were not preyed upon.

Sooty mold fungi (including Cladosporium sp.) present on the tulip tree twigs were eaten by the beetles (Table 2). The fungus-covered twig appeared to be a favorable habitat, not only for feeding but for resting and grooming, as the beetles spent a good portion of their time on it. However, the fungal growth on Camellia and oak leaves was not fed on. Beetles appeared to feed on fungi when a good growth of mycelia was present, as on the terminal bud of an oak twig.

Food Consumption in the Spring. In contrast to our fall observations, both male and female adult beetles ate all stages of scale insects in the spring, including a male pupal case of P. quercifex. Teneral females of P. quercifex were most often their food source (Table 3). The beetles readily chewed a hole in either the anterior or posterior end and consumed the entire female in one day, with two beetles sometimes feeding simultaneously on one female scale insect. Teneral females of P. hemicyphus were also consumed, but were not chosen as often as P. quercifex. We did not see beetles eating teneral females of K. kingi, although it is likely that they do.

Eggs of *P. quercifex* were also eaten more often than those of *K. kingi* or *P. hemicryphus* (Table 3). Beetles chewed a hole in the scale exoskeleton and then began eating the eggs, moving farther in as the eggs were consumed, rather than pulling the eggs out to feed on them. During the fall beetles were observed pulling eggs out, not to eat but to use the emptied scale exoskeleton as a shelter.

We recorded only a few instances of beetles eating nymphs of scale insects, of *P. quercifex* and *P. hemicryphus*, but not of *K. kingi*. The latter are probably eaten, but our observations were not extensive enough to detect it. Beetles also ate exoskeletons of postreproductive female scale insects.

Beetles visited the honeydew produced by the *C. hesperidum* females on the cyclamen leaf much more often than the honeydew from the other scale insects. We are not sure why this source was preferred, but it would be interesting to find out if it had a higher sugar content than the other honeydews, because tests with artificial honeydew solutions in the fall showed that beetles chose those with a higher sugar content over those with a lower.

Natural growths of sooty mold fungi on twigs were eaten by beetles, but not to the extent that scale insects were (Table 3). For the first time we observed beetles apparently consuming the plant exudate from a cut oak twig. This has never been reported before to our knowledge and should be investigated further.

The larvae of these beetles are known in Europe and Eastern Kazakhstan (USSR) to feed on the eggs of at least 14 species of soft scales (Coccidae) - 5 species of *Eulecanium*, 1 *Nemolecanium*, 2 *Parthenolecanium*, 3 *Physokermes*, 1 *Pulvinaria*, and 2 *Rhodococcus*. They also attack 1 species of *Kermes*, family Kermesidae (Prell 1925; Schmutterer 1952; Matesova 1966; Klausnitzer & Forster 1976; Kosztarab & Kozar 1978). Telenga (1954) and Forster (1973) also listed first instar soft scales as their food source.

Only scanty and conflicting literature records are available on the spring feeding habits of the adults before oviposition. For example, as food for the adult beetles honeydew was given by Schmutterer (1952) and Forster (1973), and remains of old hardened exoskeletons ("mummies") of adult females listed by Schmutterer (1952), Forster (1973) and Goanca et al (1974). In addition, Schmutterer (1952) and Forster (1973) named the leftover scale eggs, while Goanca et al (1974) listed overwintered scale insect nymphs. In contrast, Kiss (as reported in Illes et al, 1896) stated that the adults fed neither on scale eggs, nor on young nymphs.

In Moldavia, USSR, (Goianca et al 1974), adult beetles fed until oviposition on overwintered nymphs of the scale insects *Parthenolecanium corni* (Bouché) and *Eulecanium tiliae* (L.) (Schrank). After oviposition, the exhausted adult beetles frequently consumed honeydew, chewed into the scale insects (*Physokermes piceae* Schrank) and fed on their eggs and on the leftover exoskeleton of the females in Germany (Schmutterer 1952).

Our observations indicate that food preferences of adult beetles are different after overwintering, the primary spring food being live scale insects and their honeydew, with fungi constituting a minor part of their diet. Nevertheless, these

Table 3. Food Choices of Anthribus nebulosus Beetles in the Spring,  
As Per Cent of Total Number of Feeding Observations\*

Species of Scale Insect	Stage of Insect					Honeydew		Sooty Mold Fungi	Twig Exudate
	Pupal Case	Egg	Nymph	Teneral Female	Female Exoskeleton Only	From Scale Insects on Twigs	From Scale Insects on Leaf		
Parthenolecanium cornifex (on oak twig)	0.8	9.5	2.4	31.5	4.7	5.5		3.2	1.6
Kermes kingi (on oak twig)	•	0.8			2.4			1.6	
Physokermes hemichryphus (on spruce twig)		0.8	0.8	3.9	5.5	3.2		3.2	
Coccus hesperidum (on cyclamen leaf)							18.9		
Totals	0.8	11.1	3.2	35.4	12.6	8.7	18.9	8.0	1.6

\*Based on records for 18 beetles.



beetles have kept their original fungal feeding habit which is characteristic of the family Anthribidae or Fungus Weevils. The family, primarily of tropical and semi-tropical distribution, is common in tropical rain forests because of the high humidity which favors fungal growth. It is speculated here that *A. nebulosus* has adapted more recently to the temperate zones of Eurasia, where in the semiarid areas their primary food source of fungi is scarce. Thus, they may have secondarily adapted to feeding on scale insects to supplement their original diet. The same reason could be used to explain how some species of Anthribidae have adapted to feed on dried fruits in Australia and New Zealand. The slow-moving nymphs and their sedentary females in soft scales and *Kermes* appear to be ideal prey for this slow-moving and non-aggressive predator.

Site Preferences. Although the surface area of the twigs present with the beetles in the fall tests was not measured, it was obvious that all of them combined did not make up an area equal to half of the filter paper area. Our observations indicated that beetles preferred being on twigs to being in the open (Table 1).

Interactions. Beetles were generally solitary and non-aggressive during the fall. When two met head on, they stopped and one or both would go around the other. Although four dishes (14 cm diameter) contained five beetles for six weeks, there was only one occasion when one beetle was seen interacting physically with another. In that case the first beetle had its front legs on the back of the second for a short while before moving away.

When several beetles were inside the same black shelter, they seemed to be clustered, but this may have been because the shelter was relatively small. Close clustering was also observed by us when beetles were inside corrugated paper rolls during summer and winter diapause.

Under natural conditions, 2 beetles occasionally use the same exoskeleton of a *Physokermes* female as a shelter. No signs of cannibalism were shown by adult beetles kept in captivity, or outdoors under natural conditions.

Weight and Size. The average weight of a beetle in mid-November was 3.6 mg ( $N = 74$ ). The average weight of the ten largest beetles was  $5.9 \pm 1.1^*$  mg; of the 10 smallest,  $2.1 \pm 0.7^*$  mg. The mean length of the ten largest beetles was  $4.6 \pm 0.1$  mm; mean width  $2.0 \pm 0.1$  mm. For the 10 smallest beetles mean length was  $3.4 \pm 0.2$  mm, and the mean width  $1.4 \pm 0.1$  mm.

Secondary Sexual Dimorphism. The ability to distinguish the sexes by external features would be very helpful, and two characteristics have been suggested. Dr. Arpád Szentesi (Hungarian Research Institute of Plant Protection) used the presence of a slight curvature at the tip of the abdomen in males (personal communication). A second character used by Dr. Barry D. Valentine (Ohio State University) is sternites IV and V being longer along the midventral line in females (personal communications). We tried sexing the 10 largest and 10 smallest beetles by using both of these methods, then dissected them to determine sex.

Overall size turned out to be unacceptable for determining sex in our sample since 50% of both large and small beetles were males. Forster (1973) in Germany also found no differences in size between the sexes. The curvature at the tip of the abdomen

was unclear in 25% of the beetles in our sample. However, when the abdomen was definitely turned down, in every case the beetle was a male. One beetle classified in the "abdomen not turned down" category was found to be a male also. Thus this character is not very reliable for beetles which have no curvature or only a very slight curvature of the abdominal tip. A larger sample of beetles should be studied to test this correlation.

Measurements of the widths along the midventral line of abdominal sternites IV and V showed females averaging  $0.42 \pm 0.11$  mm for IV and V combined, and males  $0.32 \pm 0.06$  mm. A student's t-test on these data revealed no significant difference at  $\alpha=.05$ . We also found that when sternite IV was wide, sternite V was not correspondingly wide. Thus, from our limited sample we concluded this method of determining sex was not reliable either.

Grooming. The tarsi, antennae, palps and other mouthparts became sticky when feeding on honeydew, and also after holding mouthparts for some length of time just over the anal plate area of soft scales. Only self-grooming was observed, never mutual grooming.

After feeding on honeydew produced by *P. quercifex*, the beetles were observed cleaning the tarsi of the anterior legs between their mandibles by pulling the tarsi repeatedly through the mouthparts. The same procedure continued next on the midleg tarsi. The insects were able to reach and clean even the femora of the midlegs between their mandibles by lowering and bending the head underneath the body. Antennae were cleaned after feeding on honeydew by bending these in a semicircular fashion to fit between the mandibles and pulling them repeatedly between the mandibles with a combing motion.

Mating Behavior. Nine beetles of the original 18 present in the spring tests were observed in copula, and twenty-six copulations were recorded, the first on April 14 and the last on May 3. No time of the day was preferred. Of the four male beetles, only one mated with more than one female. the number of copulations per male beetle ranged from one to six. All five females had just one partner except for one which mated with two males. Number of copulations per female was one to four.

No beetle copulated more than once in the same day during the hours of observation. Length in copula ranged from 3 minutes to 35 minutes. The male mounted the female from the back, clasping her with his first and second pairs of legs, and rapidly tapping her back with his antennae. The female would sometimes begin walking around the dish during mating, dragging the male along. No difference in size was noticed between members of copulating pairs.

Development. Schmutterer (1952) reported that the female beetle chewed a hole in the still semi-soft exoskeleton of the female scale insect, and laid an egg inside the brood chamber of the scale and closed the wound with a secretion. The egg laying sites showed later only as darker spots on the female's exoskeleton. Other authors did not elaborate on the mode of egg laying.

Only two of our five mated females laid an egg that could be visually detected, one on May 7 and one on May 11. The preoviposition period after mating was 8 days in one case and

about 15 days in the other. One egg was laid on top of a dead *P. quercifex* teneral female. The egg was oval, 0.8 mm long and 0.4 mm wide. Its color was light yellow (Munsell, 1965), hue 7.5, value 8, chroma 4. This egg was moved by us from the open to under a large *P. quercifex* female with many eggs under her, but it never hatched.

A second egg was laid on a spruce twig, a short distance from a *P. hemichryphus* female. This egg remained the same for three days and then changes were noted. The outlines of the body and red eye spots appeared. By the fourth day the egg hatched and a clear case was left on the twig. The larva chewed a hole in the exoskeleton of a *Physokermes* female and went inside to feed on the eggs. After just one day the beetle larva disappeared and we were unable to find it again.

A second larva, that hatched from an undetected egg, was found on May 7 under a *P. quercifex* female filled with eggs and with a large hole chewed on her lateral side. The length of the larval and pupal stages could not be determined separately for this individual beetle because it was not always found when observations were made. However, because the pupa was discovered on May 30 and the adult emerged on May 31, the combined length of the larval and pupal stages were calculated to be about four weeks. It took about 6 hours for the newly molted adult beetle to change to its natural dark color. About 24 hours after emergence, it was eating a *P. quercifex* female, and the next day was feeding under a scale exoskeleton full of egg shells and nymphs of *P. quercifex*. On June 3 the beetle became motionless inside a *P. quercifex* exoskeleton which was detached from the twig and lying on the bottom of the dish. It remained there until June 18 when it was found lying still in the open.

The larvae pupated in mid-June and adults emerged the end of June in Moldavia (Goanca et al 1974). Adults emerged from mid-July to early August in Eastern Kazakhstan (Matesova, 1966). Schmutterer (1952) and Forster (1973) in Germany found pupae in June-July and the adults emerged a few weeks later.

Longevity. Of 12 adult beetles the average longevity after overwintering was 47 days (range 14 to 120 days) and was about the same for both males and females.

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**Annual Production and Phytoplankton Studies Within  
the Barrier Islands of Virginia, U.S.A.**

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ABSTRACT

Phytoplankton primary production rates were determined within the Barrier Islands complex of Virginia. The total production rates followed seasonal changes in water temperature. The production rates ranged from a low of approximately  $1 \text{ mg C/m}^2/\text{hr}$  in February to a high of  $290 \text{ mg C/m}^2/\text{hr}$  in June. Total annual production rate was  $178 \text{ g C/m}^2/\text{yr}$ . The concentration of phytoplankton varied seasonally, but did not coincide directly to the periods of peak production.

INTRODUCTION

Previous investigators have indicated the importance of phytoplankton to productivity within estuaries along the eastern coast of the United States (Stross and Stottlemeyer, 1965; Thayer, 1971; Thomas, 1966). The significance of detrital substances produced by phytoplankton within Georgia estuaries has been further discussed by Haines (1977). She indicates the total input of organic matter to Georgia estuaries by the phytoplankton is greater than what has been generally considered, and places a lesser emphasis on the contributions of organic matter by the *Spartina* salt marsh to these estuaries. Productivity rates in estuaries along the United States east coast have generally been higher than those taken from stations over the shelf (Riley, 1956; Smayda, 1957; Sellner et al., 1976). One of the highest values was recorded by Thomas (1966) when he reported  $546 \text{ g C/m}^2/\text{yr}$  in the Altamaha River in Georgia. Considerably lower rates have been reported in the Beaufort, N.C. estuary where annual production rates of 53 and  $67 \text{ g C/m}^2$  were determined by Williams (1966) and Thayer (1971). In a South Carolina estuary, Sellner et al. (1976) found productivity rates generally followed the annual temperature cycle, having a range between 6.4 to  $234 \text{ mg C/m}^2$ , with the total annual production of phytoplankton calculated to be  $346 \text{ g C/m}^2$ .

One significant estuarine area of the east coast that lacks productivity information is the Barrier Island complex of Virginia. Beginning at the Chesapeake Bay entrance and extending 120 km northward to the Maryland border, the barrier island chain encloses approximately  $700 \text{ km}^2$  of low land salt marsh that is interlaced with numerous channels. To determine the primary production rates within the channels of this area, a one year study was undertaken in conjunction with a total phytoplankton survey. Comparisons were made between these primary production rates, and the composition and concentration values of the phytoplankton.

## METHODS

The study area is located near the town of Oyster, Virginia, approximately 23 km north of Cape Charles. Eight stations were established in waterways that included Sand Shoal, Eckichy, and Mockhorn channels located between Oyster and Cobb Island (Fig. 1). Samples were taken at mid-channel locations during 10 collection trips spaced between November 1978 and October 1979.

A 500 ml water sample was taken at the surface at each station for phytoplankton analysis. The samples were preserved immediately with buffered formalin and returned to the laboratory for settling. A modified Utermöhl method was followed in which the samples were allowed to settle, then siphoned to a 20 ml concentrate. The concentrate was transferred to a settling chamber and subsequently examined with a Zeiss inverted plankton microscope. The entire bottom slide was scanned, with the exception of the more highly concentrated samples where subsamples were used. Phytoplankters were identified and counted to obtain cell numbers per liter.

Twenty-five ml water samples were collected from the surface for primary production analysis. These samples were placed into 125 ml glass-stoppered bottles and inoculated with 3 to 5  $\mu\text{Ci NaH}^{14}\text{CO}_3$  (specific activity 56  $\mu\text{Ci}/\mu\text{mole}$ ) and incubated from 3 to 5 hr in the time span 0900 to 1500 hr in natural light. Duplicate light and dark samples were set up. These samples were filtered through 0.45  $\mu\text{m}$  millipore filters at vacuum pressure less than 60 mm of Hg. Filters were washed with 0.1 M HCl and placed in scintillation vials containing 10 ml of scintillation fluid (6 g of 2,5-diphenyloxazol and 100 g of naphthalene/liter 1,4-dioxane). One ml aliquots of acidified, air-bubbled filtrate were pipetted into scintillation vials containing scintillation fluid. The  $\text{C}^{14}$  found in these vials was used to determine the dissolved organic  $\text{C}^{14}$  (DOC) released. Annual production rates were calculated by multiplying the mean fixation/ $\text{m}^2\text{hr} \cdot 12\text{hr}/\text{d} \cdot 365\text{d}/\text{y}$ .

Salinity and temperature values were obtained with a portable Beckman salinometer (Model R55-3). A model 126A Photovolt portable pH meter was used for pH readings, and a standard sized secchi disc for visibility.

## RESULTS

Total production rates followed seasonal changes in water temperature (Fig. 2). The samples showed a decrease in the total productivity rates from the Fall of 1978 into Winter, which corresponded to a decrease in water temperature. This productivity was from 9.5  $\text{mg C}/\text{m}^2/\text{hr}$  on 15 November 1978 to 1.2  $\text{mg C}^2/\text{m}^2/\text{hr}$ . on 12 February 1979. During Spring the total rate of productivity increased from 16.8  $\text{mg C}/\text{m}^2$  in April to 290  $\text{mg C}/\text{m}^2/\text{hr}$  in June 1979, which corresponded to an increase in water temperature. From 13 August to 3 October 1979 the total productivity rates declined. Maximum rates were recorded on 24 June 1979 with Station 7 showing the highest rate, 348.6  $\text{mg C}/\text{m}^2/\text{hr}$  (Table 1). Minimum rates were observed at the times of collection on 21 February 1979 and 19 March 1979 for all stations sampled. Monthly differences occurred in the amount of  $\text{C}^{14}$  fixed by the phytoplankton at the various stations, with the annual production rate for this study 178  $\text{g C}/\text{m}^2/\text{yr}$ .

The concentration of phytoplankton varied seasonally, having growth pulses occurring in January, March, and August. Maximum numbers were recorded on 19 March 1979 with average counts for all stations approximately  $1.89 \times 10^6$  cells/l (Fig. 2). The seasonal lows occurred in December, February, and June. Species composition was predominated by forms characteristic of shelf populations and previously reported by Marshall (1976), and Marshall, Nesius and Cibik (1981). These mainly were nanoplankton sized diatoms that included *Leptocylindrus danicus*, *L. minimus*, *Asterionella glacialis*, *Skeletonema costatum*, *Rhizosolenia delicatula*, and *Cylindrotheca closterium*. Diatoms were dominant during all seasons. The winter peak of January consisted mainly of nanoplankters dominated by

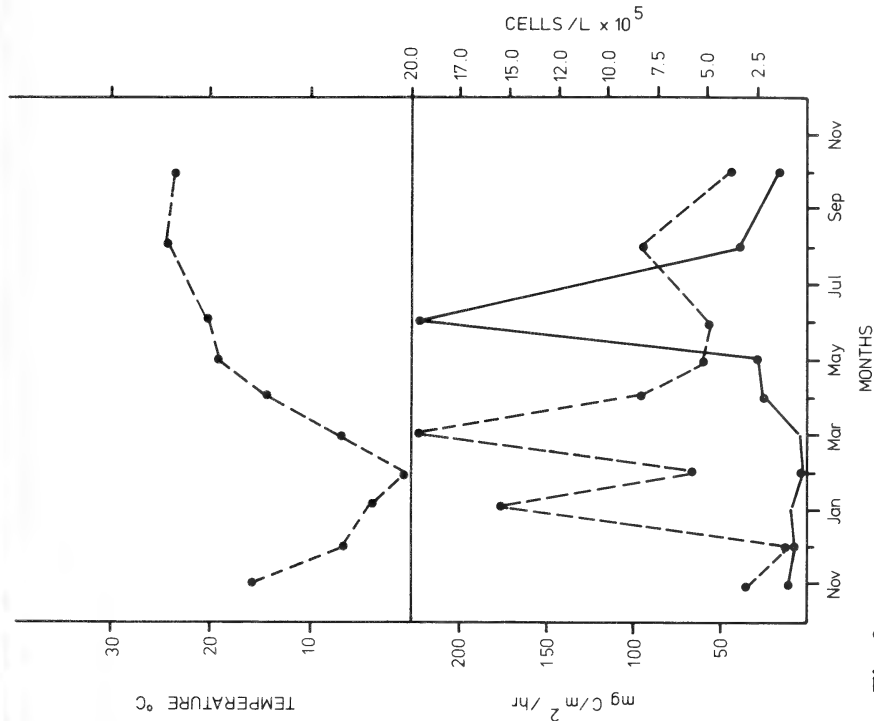


Fig. 2

Seasonal cycle of total production rates (—), concentrations of phytoplankton (---) and water temperature in Virginia Barrier Islands (mean of all stations).

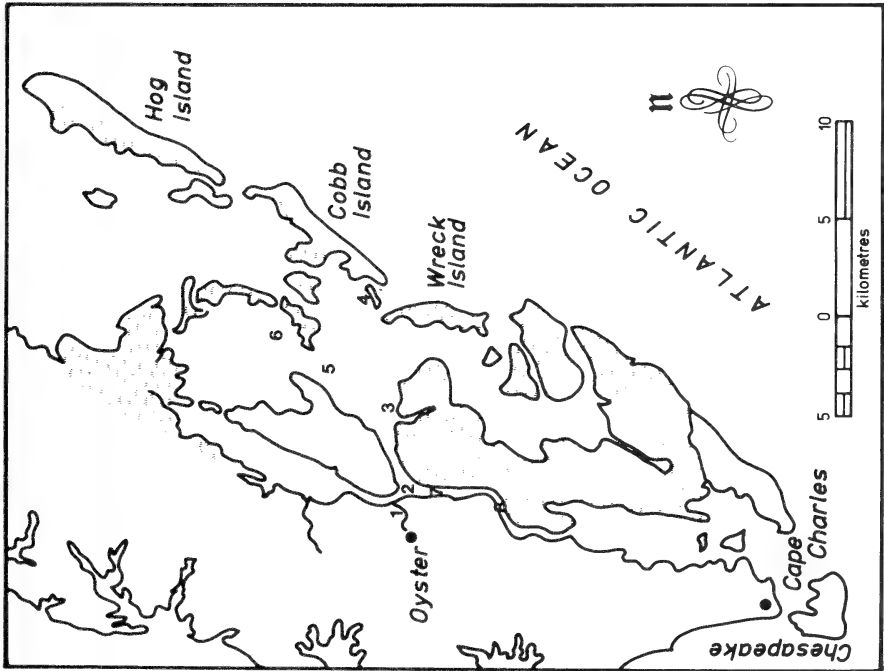


Fig. 1

Map of Barrier Islands of Virginia U.S.A. Numbers indicate the sampling stations.

Table 1. Total production rate for each station (mg C/m<sup>2</sup>/hr).

DATE	STATION							
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
15 Nov 78	14.81	13.12	14.21	16.21	9.41	4.10	2.67	1.38
12 Dec 78	4.12	7.52	3.11	7.54	3.31	3.53	5.72	5.61
10 Jan 79	6.23	5.23	3.01	2.36	11.23	8.81	4.16	2.89
21 Feb 79	1.22	.88	1.19	1.53	-	-	-	-
19 Mar 79	1.43	2.12	1.51	2.36	2.21	1.43	.89	1.31
23 Apr 79	19.61	17.23	10.21	17.99	13.83	14.18	12.32	29.13
22 May 79	24.62	25.08	17.63	18.15	10.31	13.42	21.11	20.84
24 June 79	230.31	263.87	231.63	238.31	348.66	-	371.28	352.82
13 Aug 79	8.78	10.42	44.18	62.91	26.71	79.85	61.42	18.13
3 Oct 79	10.21	10.05	17.81	18.68	-	-	29.31	23.39



*Leptocylindrus danicus*, *L. minimum*, *Asterionella glacialis*, and *Rhizosolenia delicatula*. Basically the same populations, but in much lower concentrations, were noted in the February collection which coincided with low productivity values and temperatures of 0°C. March was accompanied by rising temperatures and a major increase in phytoplankton numbers, but no major increase in productivity was noted at that time. The phytoplankton composition in March consisted of a combination of the same species as the winter peak, plus several *Chlorella* spp., and other ultraplankton components.

The prominent diatoms consisted of filamentous or colonial forms. Clusters, or groups of other phytoplankters were typically found, indicating conditions favorable for rapid multiplication. Subsequent collections from April through June indicated a decrease in cellular counts and a transition to a larger sized diatom community. Many of the past prominent species were still among the dominants (*S. costatum*, *R. delicatula*, *L. minimum*, *R. setigera*), however several *Chaetoceros* species and *Guinardia flaccida* were also common. This seasonal successional pattern was similar to that outlined by Margalef (1958) with the exception that there was no significant increase in the concentrations of dinophyceans into summer. Instead the summer dominants were mainly larger sized diatoms (e.g. *Chaetoceros* spp., *Corethron hystrix*, *Lithodesmium undulatum*), with the appearance of the cyanophycean *Nostoc commune*, which persisted into fall. The highest productivity rate occurred in June. This coincided with a decreasing population level, which averaged  $5 \times 10^5$  cells per liter at each station. This was followed by a moderate fall pulse where the same nanoplankton forms again became dominant.

#### SUMMARY

The monthly primary production rates followed a seasonal pattern that corresponded closely to temperature. The productivity rates decreased with a decline in temperature into winter and rose with the increased temperatures into summer, then dropped again into late fall. The phytoplankton levels were generally high throughout the study, exhibiting seasonal changes in population concentrations, having pulses in winter, spring, and fall. The occurrence of the periods of greater phytoplankton concentrations did not appear to effect the periods of peak productivity, which did not coincide with maximum population size. The channels in this study were dominated by a diatomaceous flora, characteristic of forms found over the shelf. The data indicates an annual production rate for these channels to be  $178 \text{ g C/m}^2/\text{yr}$ . This rate is within the range found by other investigators for other coastal estuaries on the United States east coast (Smayda, 1957; Thayer, 1971; Williams, 1966; Thomas, 1966; and Sellner et al., 1976).

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**Seasonal Changes in the Phytoplankton of  
Lake Chesdin, Virginia with Ecological Observations**

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**Abstract**

The phytoplankton of Lake Chesdin was observed to be quite diverse with 339 species and varieties identified. The dominant alga, *Melosira granulata* var *angustissima* displayed large pulses during autumn and late spring at the shallower collection sites. The seasonal range in physical ecological factors such as sunlight, water temperature, and turbidity resulted in considerable variations in phytoplankton standing crop. The lowest standing crop of 45 cells/ml was observed in January, 1975, while the largest standing crop ( 3500 cells/ml) occurred during October, 1974. Water temperatures ranged from an average of 30C during late summer to 3.2C during midwinter which resulted from the shallowness of the lake, the small drainage area of the Appomattox River above the lake, and the short hydraulic retention time of the lake.

**Introduction**

Lake Chesdin, Virginia, is a man-made reservoir created by the damming of the Appomattox River in 1967. Since the lake serves a vital role to the Tri-Cities of Colonial Heights, Hopewell, and Petersburg, Virginia, by being its principal source of public water supply, information regarding its relative ecological condition would be invaluable. One method of determining the ecological condition of any lake is to make an annual study of the phytoplankton, the primary producers in most aquatic ecosystems. Therefore, the purposes of this study were:

1. To identify all algal species encountered in the plankton of Lake Chesdin,
2. To monitor and quantify the populations of individual algal genera, and,
3. To relate populations of the algal genera encountered to seasonal ecological factors that might influence their populations.

**Description of the Lake**

Lake Chesdin is located at approximately 77° 35' West longitude and 37° 15' North latitude or about 17 km west of Petersburg, Virginia.

The lake (Fig. 1) follows the flood plain of the Appomattox River which gives the body of water a long (28km), narrow (less than 1 km) shape with a surface area of 12.95 km.<sup>2</sup> The dam impounds about  $90 \times 10^6$  m<sup>3</sup> of water with the maximum depth of 14 m occurring at the dam. The upper 12 km of Lake Chesdin is a broad, extremely shallow area, often less than 2 m deep. Except during extremely dry summers, the water level exceeds the height of the dam which imparts a flowing nature to the impounded water and, therefore, a short hydraulic retention time.

The flowing nature of Lake Chesdin does not allow the development of a strong thermocline. However, a clinograde dissolved oxygen stratification does occur with the bottom becoming anaerobic.

#### Materials and Methods

Five collection sites (Fig. 1) were chosen with regard to the general morphometry of the lake. Qualitative phytoplankton samples were obtained by trolling at low speed in a motor-driven boat with a No. 25 mesh phytoplankton tow net over an unmeasured distance. The resulting concentrated samples were stored in 100 ml collection bottles and observed in a living condition. Species identifications of the diatoms were determined following acid clearing and mounting in Hyrax.

Quantitative phytoplankton and water samples were collected by the use of a model 1200 modified Kemmerer sampler and transferred to collection bottles. Samples were collected at each site at the water's surface and depths of 1 and 3 meters. Phytoplankton counts were obtained by pipeting 50 ml sub-samples into centrifuge tubes and gently centrifuging at 1000 rpm for 20 minutes in an International Portable Refrigerated Centrifuge Model PR-2 that was calibrated to existing lake water temperatures. Algal residues were resuspended in a volume of 5 or 10 ml of filtered lake water depending upon the anticipated phytoplankton density. One tenth ml of this concentrated sample was placed in a Palmer-Maloney nanoplankton counting chamber and the algal genera identified, counted, and expressed as cells/ml for each of 3 replicate counts. The expression of algal counts as cells/ml rather than organisms/ml emphasizes the larger biomass of filamentous and colonial algae in comparison to unicellular forms. The small cell size of certain blue-green algae (e.g. *Aphanizomenon*) required that these be reported as filaments or colonies/ml.

Water chemistry determinations (Table I) utilized the Hach water pollution test kit calibrated to standard methods (1). Dissolved oxygen and temperature were determined with a Yellow Springs International Oxygen meter Model 51-A. Hydrogen ion concentration was determined with a Beckman Zeromatic pH meter Model 6804.

#### Results

Appendix I lists the species of algae encountered as plankton in Lake Chesdin during the period from October 2, 1974, to August 4, 1975, with the months observed designated. Table II gives a breakdown of the identified algal species and varieties into important taxonomic groups. Many of the algal forms identified are not considered true plankton (euplankton) as for example many desmids (Zygnematales) and diatoms (Bacillariophyceae), both of which were represented by species considered to be tychoplankton or meroplankton.

The standing crop (Fig. 2) was dominated by the diatoms, in particular the centric diatom, *Melosira granulata* var. *angustissima* Muller. This filamentous species displayed significant pulses at sites 4 and 5 during both autumn and late spring when it often comprised 90% of the standing crop. Table I demonstrates the average number of cells observed during each "season" for the major taxonomic groups of phytoplankton in Lake

Figure 1

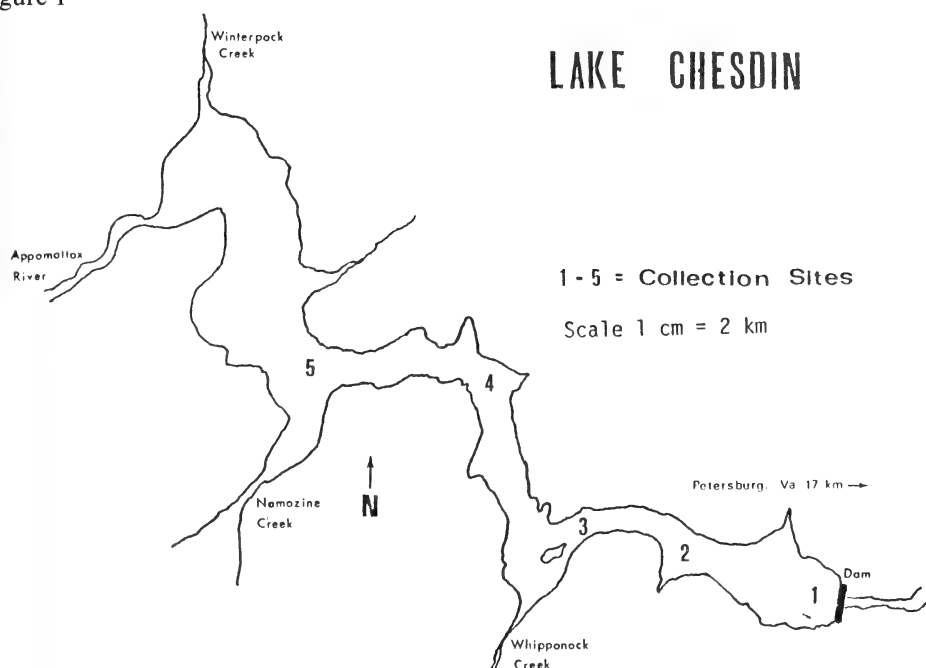
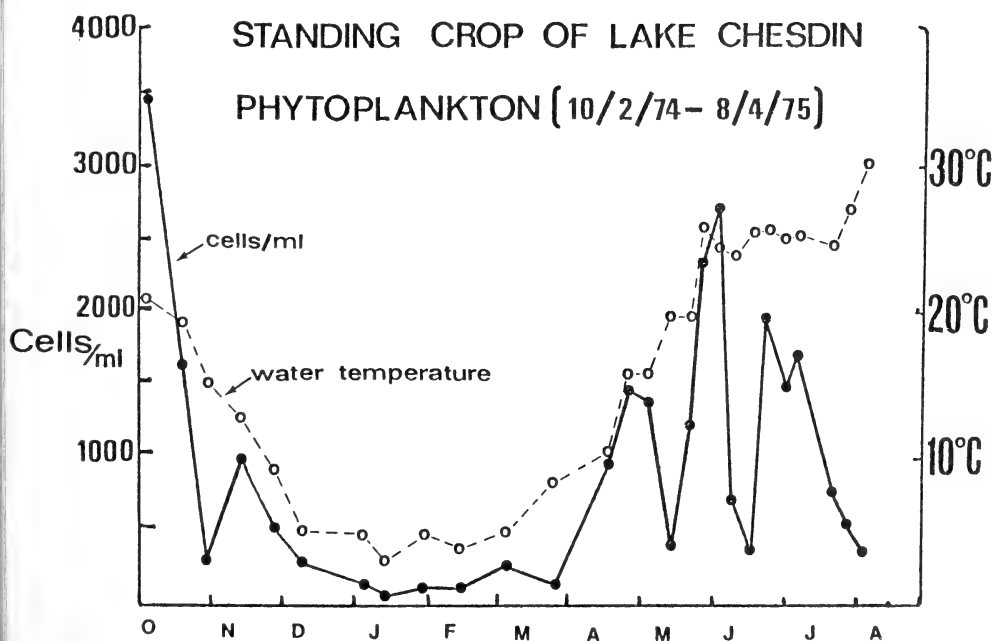


Figure 2



Chesdin. These seasons were based upon average water temperatures since this measurement best reflected the physical changes that occurred during the study period. The short autumn and spring seasons reflected the relatively small drainage area of the Appomattox River above Lake Chesdin as well as the shallowness of the lake itself. Table III lists the most abundant phytoplankton genera during each season.

Physical and chemical analyses are given in Table I. The extremely high turbidity, often observed following period of heavy precipitation, indicates that the lake drainage area contains much disturbed land which is susceptible to erosion. During May, June, and July, 1975, the Appomattox River Water Authority treated the lake with large amounts of copper sulfate in order to inhibit the growth of potential "taste and odor" producing algae. These applications possibly accounted for the unusual fluctuations observed in the standing crop (Fig. 2) during these months. The use of copper sulfate as a potent algicide has existed for some time (2) and this compound has been shown to inhibit growth of *Anabaena flos-aquae* at lower concentrations than for the green alga *Chlorella* (3). The copper sulfate applications were devastating to certain algal forms (*Melosira granulata* and *Asterionella formosa*) while other genera (*Scenedesmus* and *Ankistrodesmus*) were much more tolerant. The copper sulfate applications often masked natural variations in standing crop at the different collection sites (Table IV).

#### Discussion

The phytoplankton of Lake Chesdin closely resembled the description of North Carolina lakes and ponds by Whitford (14) although it differed markedly from the phytoplankton of the two natural lakes of Virginia, Lake Drummond (5) and Mountain Lake (6). Dystrophic Lake Drummond is dominated by the diatom, *Asterionella formosa*, which experiences large pulses during May, June, and September (5). Mountain Lake is dominated

Table I

Title: Average Seasonal Phytoplankton Composition and Physical-Chemical Results (Seasons based on Water Temperature) N = 15 Samples/Collection Date.

	Fall	Winter	Spring	Summer
Collections	5	7	5	10
Inclusive Dates	10/2/74- 11/26/74	12/2/74- 3/26/75	4/16/75- 5/19/75	5/26/75- 8/4/75
Range of water temperature (°C)	9.6-20.0	4.4-8.6	11.0-21.3	25.8-30.4
Total standing crop (cells/ml)	1456.1	184.0	1134.5	1342.4
Chlorophyta	20.9	4.3	87.8	181.9
Chrysophyta (w/o diatoms)	10.4	26.3	134.3	56.8
Bacillariophyceae	1397.2	149.1	865.4	1045.5
Euglenophyta	21.9	1.7	18.5	43.6
Pyrrhophyta	0.3	0.1	2.7	6.9
Cyanophyta	5.4	0.0	1.3	2.4
Cryptophyta	0.0	2.5	24.5	5.3

#### Chemical-Physical Results

pH	7.0	7.1	7.4	7.3
Average temperature (°C)	15.4	5.6	17.6	26.9
NO <sub>3</sub> -H (mg/l)	0.49	0.69	NA	NA
NH <sub>3</sub> -N (mg/l)	0.38	0.89	0.81	0.41
PO <sub>4</sub> -P (mg/l)	.020	.029	.052	.027
Calcium hardness (mg/e)	15.3	12.9	16.1	19.8
Dissolved oxygen (mg/l)	NA	12.1	8.7	7.4
Secchi disk (cm depth)	NA	69.6	97.2	131.1

NA = Not Available

Table II

Title: Summary of Lake Chesdin Algae Encountered as Plankton

Division	Important Classifications	Total Number of Forms	Per cent of Total
Chlorophyta			
Volvocales	13	152	44.88
Tetrasporales	3		
Ulotrichales	2		
Oedogoniales	2		
Chlorococcales	72		
Zygnematales	60		
Euglenophyta		42	12.4
Chrysophyta		116	34.2
Xanthophyceae			
Chrysophyceae			
Bacillariophyceae			
Pyrrhophyta		12	3.5
Cryptophyta		2	0.6
Cyanophyta		15	4.4
		339	99.9

Table III

Title: Most Common Algal Genera by Season (cells/ml Average Values Based on 15 Samples/Collection Date)

Fall		Winter		Spring		Summer	
<u>Melosira</u>	1388.4	<u>Melosira</u>	109.7	<u>Melosira</u>	732.7	<u>Melosira</u>	950.
<u>Eudorina</u>	16.7	<u>Synura</u>	22.5	<u>Synura</u>	75.6	<u>Synedra</u>	63.
<u>Trachelomonas</u>	13.7	<u>Synedra</u>	15.0	<u>Synedra</u>	74.8	<u>Scenedesmus</u>	33.
<u>Synura</u>	9.3	<u>Asterionella</u>	14.2	<u>Asterionella</u>	32.3	<u>Lagynion</u>	28.
<u>Euglena</u>	8.4	<u>Fragilaria</u>	5.7	<u>Cryptomonas</u>	24.5	<u>Trachelomonas</u>	19.
<u>Aphanizomenon</u>	5.3 <sup>a</sup>	<u>Dinobryon</u>	2.9	<u>Uroglenopsis</u>	22.3	<u>Coelastrum</u>	18.
<u>Synedra</u>	4.1	<u>Cryptomonas</u>	2.5	<u>Eudorina</u>	16.6	<u>Ankistrodesmus</u>	18.
<u>Dinobryon</u>	1.4	<u>Eudorina</u>	1.2	<u>Scenedesmus</u>	14.4	<u>Cyclotella</u>	17.
<u>Pediastrum</u>	1.2	<u>Trachelomonas</u>	1.0	<u>Trachelomonas</u>	13.9	<u>Micratinium</u>	13.
<u>Fragilaria</u>	1.1	<u>Mallomonas</u>	0.9	<u>Fragilaria</u>	13.7	<u>Dinobryon</u>	11.
				<u>Pandorina</u>	13.6	<u>Crucigenia</u>	11.
						<u>Synura</u>	10.

a = Filaments/ml

Table IV

Title: Total Standing Crop at Collection Sites by Season (cell/ml) Average Values Based on 3 Depths/Collection Date

Collection Site	Fall	Winter	Spring	Summer	Water Depth
# 1	1537.5	586.0	1742.2	1208.4	12 m
# 2	1692.4	600.1	2241.2	1430.6	9 m
# 3	4623.2	817.7	3024.8	1794.6	5.5 m
# 4	6065.8	333.4	3689.2	5208.4	3.7 m
# 5	7839.4	427.9	6280.2	10505.4	2.2 m

by the centric diatom, Cyclotella comta, and the green algae, Sphaerocystis schroeteri and Planktosphaeria gelatinosa, but the phytoplankton densities of this oligotrophic lake are extremely low (6). Lake Chesdin is a soft-water lake (e.g. 15mg/l calcium hardness) and is very typical of the larger man-made lakes throughout the piedmont of the Southeastern United States (4). The dominant alga of Lake Chesdin, Melosira granulata var angustissima, has been reported (4) as being abundant in many rivers and lakes throughout this region. The high number of phytoplankton forms observed (339) indicates that the flora of the lake was quite diverse although many of the forms encountered were not euplanktonic. Since a member of the genus Melosira was the dominant plankter and the standing crop was relatively large, the phytoplankton association of Lake Chesdin fits Hutchinson's description (7) of a eutrophic diatom association.

The seasonal variation in standing crop was extremely large, ranging from very low numbers of cells in midwinter to counts of 10,000 cells/ml during early autumn and late spring. The lowest standing crop (45.4 cells/ml) occurred when the average water temperature dropped to 3.2C on January 15, 1975, and undoubtedly resulted from the interactions of low temperature, low solar light intensity, and extreme turbidity. The largest standing crop occurred during October, 1974, a time when temperature (20-22C) and light intensity (moderate) were favorable for the growth of Melosira granulata var angustissima. The diversity of the autumn peak in standing crop was much lower than the late spring peak when significant populations of Scenedesmus, Coelastrum, Synedra, Dinobryon, Mallomonas, Trachelomonas and Asterionella were observed with M. granulata which, in addition, was the host for large numbers of the minute epiphyte, Lagynion reductum. The fall pulse of M. granulata was accompanied by small populations of Eudorina elegans, Euglena, Trachelomonas, and Synura.

The chemical analyses of Lake Chesdin showed that the lake was rich in nitrate-nitrogen and orthophosphate-phosphorus at all times of the year which agrees with an earlier study (8). These observations suggested that nutrient limitation as a determining factor in seasonal variations of total standing crop was highly unlikely. The Appomattox River has been described (8) as being highly silicious which indicates that adequate amounts of silica were available for extensive diatom growth. The presence of these nutrients, along with the shallowness of the upper portions of the lake which allowed the photic zone to extend to the bottom, possibly resulted in the large populations of Melosira granulata var angustissima. In addition, the higher flow rate of the water in the upper portion of the lake could have aided the suspension of this species in the water column (7) and may help to explain the disparity in populations of this species observed at the different sites when conditions were optimal for its growth (Table IV).

Although no large blooms of heterocystous blue-green algae were encountered during the study period, qualitative net tows frequently revealed the presence of Anabaena spiroides and A. circinalis when surface waters approached 30C. During the autumn, Aphanizomenon flos-aquae was observed when temperatures were as low as 13C. Pearsall (10) has reported that lakes in England dominated by Melosira granulata usually experienced large blooms of blue-greens during late summer. Possibly the extensive treatments with copper sulfate during the spring and summer of 1975 inhibited the natural growth of the blue-green species as well as other forms, and it should be pointed out that no collections were made during late August and early September when water temperatures normally are their highest (Table V).

The expansive, shallow area of the upper portion of Lake Chesdin provides an excellent environment for algal growth and probably explains the higher standing crop values observed at sites 4 and 5 than at the other sites (Fig. 2).

Extremely heavy rains during July returned the lake to the extremely turbid conditions that were present during winter and early spring. In



Table V

Title: Frequency of Collections (October 1974 - September 1975)

Month	Number of Collections	Month	Number of Collections
October	2	April	2
November	2	May	4
December	1	June	4
January	3	July	4
February	2	August	1
March	2	September	0

this turbid water, several flagellated species of phytoplankton that had disappeared during May, 1975, reappeared in large numbers. These species, including Pandorina morum, Eudorina elegans, Cryptomonas spp., Synura spinosa, and Mallomonas caudata, could have been very sensitive to high light intensities, thus preferring turbid water conditions in which light is reduced. In addition, lowered predation rates by zooplankters could have resulted from the high turbidity. Dissolved oxygen concentrations and water temperature were observed to be factors of less importance for the flagellated species since these parameters following the heavy rains varied greatly from observations made during early spring when the annual maximum in population occurred for these species.

### Conclusion

The phytoplankton of Lake Chesdin is typical of the man-made lakes of the southeast region of the United States (10). The phytoplankton association could be characterized as eutrophic diatom and possibly results from the availability of high concentrations of important limiting nutrients and from the morphometry of the lake. The relatively small drainage area of the Appomattox River above Lake Chesdin allows the lake water temperatures to closely follow the ambient air temperatures and, thus, normal seasonal changes in the physical environment result in a corresponding and immediate seasonal variation in total phytoplankton standing crop.

### Appendix I

#### Taxonomic List of Lake Chesdin Phytoplankton Observed From October 2, 1974 - August 4, 1976

(Numbers in right column = month of year observed)

\* - Diatoms identified after acid clearing

#### Chlorophyta (152)

##### Class Chlorophyceae

##### Order Volvocales (13)

##### Family Chlamydomonadaceae

<u>Chlamydomonas</u> spp. Ehrenberg	Perennial
<u>Chlamydomonas pertyi</u> Goroshankin	4,5
<u>Carteria</u> sp. Diesing	7

##### Family Oocystaceae

<u>Zoochlorella conductrix</u> Brandt	7
<u>Chlorella</u> spp. Beyerinck	3, 4, 6-8
<u>Oocystis borgei</u> Snow	6
<u>Oocystis elliptica</u> W. West	5-8
<u>Chodatella subsalsa</u> Lemmermann	6
<u>Franceia ovalis</u> (France) Lemmermann	5
<u>Radiococcus nimbatu</u> s (de Wild) Schindler	6
<u>Pachycladon umbrinus</u> G. M. Smith	5-8
<u>Ankistrodesmus braunii</u> (Naeg) Brunthaler	2

<u>Ankistrodesmus convolutus</u> Corda	5, 7
<u>Ankistrodesmus falcatus</u> var. <u>mirabilis</u> (West & West) G. S. West	1-4
<u>Ankistrodesmus nannoselene</u> Skuja	1
<u>Closteriopsis longissima</u> var. <u>tropica</u> West & West	5-8
<u>Selenastrum gracile</u> Reinsch	6
<u>Kirchneriella contorta</u> (Schmindle) Bohlin	5
<u>Kirchneriella elongata</u> G. M. Smith	6
<u>Kirchneriella lunaris</u> (Kirchner) Mobius	6
<u>Kirchneriella obesa</u> (W. West) Schmindle	5-7
<u>Quadrigula chodatii</u> (Tanner-Fullman) G. M. Smith	6
<u>Quadrigula lacustris</u> (Chod.) G.M. Smith	2-8
<u>Tetraedron caudatum</u> (Corda) Hansgirg	7
<u>Tetraedron constrictum</u> G. M. Smith	5, 8
<u>Tetraedron gracile</u> (Reinsch) Hansgirg	5-7
<u>Tetraedron planctonicum</u> G. M. Smith	8
<u>Tetraedron quadricuspidatum</u> (Reinsch) Hansgirg	7
<u>Tetraedron regulare</u> Kutzing	6, 8
<u>Tetraedron trigonum</u> (Naeg.) Hansgirg	5-8
<u>Tetraedron trigonum</u> var. <u>gracile</u> (Reinsch) De Toni	6, 7
<u>Tetraedron trigonum</u> var. <u>setigerum</u> (Arch.) Lemmermann	6, 7
Family Scenedesmaceae	
<u>Scenedesmus abundans</u> var. <u>brevicauda</u> G. M. Smith	6, 7
<u>Scenedesmus acuminatus</u> (Lag.) Chodat	1, 3, 5-8
<u>Scenedesmus anomalus</u> (G. M. Smith) Ahlstrom & Tiffany	3
<u>Scenedesmus armatus</u> (Chod.) G. M. Smith	4
<u>Scenedesmus bijuga</u> (Turp.) Lagerheim	5-8
<u>Scenedesmus bijuga</u> var. <u>alternans</u> (Reinsch) Hansgirg	6, 7
<u>Scenedesmus denticulatus</u> Lagerheim	6
<u>Scenedesmus denticulatus</u> var. <u>recurvatus</u> Schumacher	5-8
<u>Scenedesmus quadricauda</u> (Turp.) Brebisson	2, 4-8
<u>Scenedesmus quadricauda</u> var. <u>maximus</u> West & West	5, 6
<u>Scenedesmus serratus</u> (Corda) Bohlin	4-7
<u>Actinastrum gracilimum</u> G. M. Smith	4
<u>Actinastrum hantzschii</u> Lagerheim	5, 6
<u>Actinastrum hantzschii</u> var. <u>fluviatile</u> Schroeder	4-7
<u>Crucigenia opiculata</u> (Lemm.) Schmidle	7, 8
<u>Crucigenia irregularis</u> Wille	6, 7
<u>Crucigenia quadrata</u> Morren	6, 10
<u>Crucigenia tetrapedia</u> (Kirch.) West & West	6
<u>Crucigenia truncata</u> G. M. Smith	6
Family Micratinaceae	
<u>Micratinium pusillum</u> Fresenius	5-7
<u>Micratinium quadrisetum</u> (Lemm.) G. M. Smith	6-8, 10
<u>Errerella bornheimiensis</u> Conrad	6-8
Family Dictyosphaeriaceae	
<u>Dictyosphaerium ehrenbergianum</u> Nageli	5, 6
<u>Dictyosphaerium pulchellum</u> Wood	6-8
Order Zygnematales (60)	

Family Zygnemataceae	
<u>Mougeotia</u> spp. Agardh	1-3, 7, 8, 10
<u>Zygnema</u> spp. Agardh	10
<u>Spirogyra</u> spp. Link	1, 3-6, 10
Family Mesotaeniaceae	
<u>Cylindrocystis brebissonii</u> Meneghini	8
Family Desmidiaceae	
<u>Closterium abruptum</u> (Lyngb.) Brebisson	2
<u>Closterium acerosum</u> (Shrank) Ehrenberg	5-7
<u>Closterium ehrenbergii</u> Meneghini	5
<u>Closterium gracile</u> Brebisson	3
<u>Closterium gracile</u> var. <u>elongatum</u>	
West & West	2, 4-8, 10, 11
<u>Closterium gracile</u> var. <u>intermedium</u>	
Irenne-Marie	4, 6
<u>Closterium incurvum</u> Brebisson	6, 10
<u>Closterium leibleini</u> Kutzing	3
<u>Closterium lineatum</u> Ehrenberg	1
<u>Closterium lunula</u> Nitzsch	7
<u>Closterium moniliferum</u> Brebisson	11
<u>Closterium praelongum</u> Brebisson	5
<u>Closterium praelongum</u> var. <u>brevior</u> West	6
<u>Closterium pronum</u> Brebisson	5
<u>Closterium setaceum</u> Ehrenberg	11
<u>Closterium sublatum</u> (Kutz.) Brebisson	5, 6
<u>Closterium toxon</u> West	1
<u>Closterium turgidum</u> Ehrenberg	3, 4, 6
<u>Pleurotaenium trabecula</u> (Ehren.)	
Nageli	5, 10, 11
<u>Euastrum affine</u> Ralfs	12
<u>Micrasterias denticulata</u> Brebisson	7
<u>Micrasterias radiata</u> Hassall	6, 7, 10
<u>Micrasterias radiata</u> var. <u>dichomata</u>	
(Wolle) Cushman	7
<u>Micrasterias radiosa</u> var. <u>aculeata</u>	
Kreiger	7
<u>Micrasterias rotata</u> (Grev.) Ralfs	1
<u>Cosmarium</u> spp. Corda	2, 3, 5-7, 11
<u>Cosmarium botrytis</u> Meneghini	5, 7
<u>Cosmarium granatum</u> Brebisson	5
<u>Cosmarium minutissimum</u> Archer	6-8
<u>Cosmarium obtusatum</u> Schmidle	3, 5
<u>Cosmarium ordinatum</u> (Boerg) West & West	7
<u>Cosmarium subcrenatum</u> Hantzsch	5, 7
<u>Cosmarium tenue</u> Archer	6
<u>Arthrodesmus octocornis</u> Ehrenberg	3-5, 7
<u>Arthrodesmus subulatus</u> Kutzing	7
<u>Staurastrum altenans</u> Brebisson	5, 7
<u>Staurastrum americanum</u> (West & West)	
G. M. Smith	
<u>Staurastrum chaetoceras</u> (Shrod.)	
G. M. Smith	5-7
<u>Staurastrum curvatum</u> W. West	6
<u>Staurastrum dickei</u> var. <u>maximum</u> West	
& West	6
<u>Staurastrum dickei</u> var. <u>rhomboideum</u>	
West & West	7
<u>Staurastrum gracile</u> Ralfs	3
<u>Staurastrum leptocladum</u> var. <u>insigne</u>	
West & West	7
<u>Staurastrum natator</u> West	10-12
<u>Staurastrum orbiculare</u> var. <u>depressum</u>	
Roy & Bliss	

<u>Staurostrum paradoxum</u> var. <u>cingulum</u> West	7
& West	
<u>Staurostrum pentacerum</u> (Wolle) G. M. Smith	8
<u>Staurostrum punctulatum</u> Brebisson	6
<u>Staurostrum subcruciatum</u> Cooke & Wille	5-8
<u>Staurostrum tetracerum</u> Ralfs	3, 6
<u>Sphaerzosma granulatam</u> Roy & Bliss	2, 3
<u>Hyalotheca dissiliens</u> (Smith) Brebisson	2-4, 7
<u>Hyalotheca mucosa</u> (Dillw.) Ehrenberg	1, 3
<u>Desmidium aptogonum</u> Brebisson	1, 4
<u>Desmidium Baileyi</u> (Ralfs) Norstedt	3
<u>Desmidium Swartzii</u> Agardh	10

## Chrysophyta (116)

## Class Xanthophyceae (6)

## Order Heterococcales

## Family Characiopsidaceae

Characiopsis cylindrica (Lembert)

Lemmermann 3

## Family Centritractaceae

Centritractus dubius Printz 4Pseudotetraedron neglectum Pascher 5, 7Ophiocytium capitatum var. longispinum

(Moebius) Lemmermann 7

Ophiocytium desertum var. minor Prescott 7

## Class Chrysophyceae (20)

## Order Ochromonadales

## Family Ochromonadaceae

Uroglenopsis americana (Calkins)

Lemmermann 5

Anthophysa vegetans (Mull) Stein 7

## Family Dinobryonaceae

Dinobryon acuminatum Ruttner 3-5Dinobryon bavaricum Imhof 5-8Dinobryon cylindricum Imhof 1-8, 10-12Dinobryon divergens Imhof 5-8, 10, 11

## Family Synuraceae

Mallomonas acaroides Perty 4-8, 11, 12Mallomonas apochromatica Conrad 6, 10Mallomonas caudata Iwanoff 1, 2, 4-8, 10Mallomonas producta Iwanoff 6, 7Mallomonas teilingii Conrad 3Mallomonas tonsurata Teiling 5Synura adamsii G. M. Smith 7, 10-12Synura petersenii Korshikov 5Synura sphagnicola Korshikov 3-7Synura spinosa Korshikov 4-8, 10Synura uvella Ehrenberg 1-4, 7, 11, 12

## Order Chromulinales

## Family Chrysococcaceae

Chrysopyxis bipes Stein 6

## Order Rhizochrysidales

## Family Rhizochrysidaceae

Rhizochrysis limnetica G. M. Smith 7, 10

## Family Stylococcaceae

Lagynion reductum Prescott 5-8

## Class Bacillariophyceae (90)

## Order Eupodiscales

## Family Coscinodiscaceae

\*Melosira granulata (Ehr.) Ralfs Perennial\*Melosira granulata var. angustissima

O. Muller Perennial

\*Melosira varians Agardh Perennial

* <u>Cyclotella stelligera</u> Cleve & Grunow	4-8
* <u>Stephanodiscus hantzschii</u> var. <u>pusilus</u> (Grun.) Kreiger	5
Family Phacotaceae	
<u>Pteronoman sinuosa</u> Chodat	7
<u>Collomonas orbicularis</u> Stein	7, 8
Family Volvocaceae	
<u>Gonium pectorale</u> Mueller	10, 4-7
<u>Pandorina morum</u> Bory	1, 3-8, 10
<u>Eudorina elegans</u> Ehrenberg	All but 2
<u>Eudorina unicocca</u> G. M. Smith	5
<u>Volvox aureus</u> Ehrenberg	1-3, 6-8
<u>Volvox perglobator</u> Powers	7
<u>Volvox prolificus</u> Iyengar	6-8
Family Haematococcaceae	
<u>Haematococcus lacustris</u> Agardh	3, 5
Order Tetrasporales (3)	
Family Palmellaceae	
<u>Sphaerocystis Schroeteri</u> Chodat	6, 7
<u>Gloeocystis vesiculosa</u> Naegeli	7
<u>Asterococcus limneticus</u> G. M. Smith	6-8
Order Ulotrichales (2)	
Family Chaetophoraceae	
<u>Draparnaldia</u> sp. Bory	5
Family Protococcaceae	
<u>Protococcus</u> sp. Agardh	5
Order Oedogoniales (2)	
Family Oedogoniaceae	
<u>Oedogonium</u> spp. Link	2-7, 10
<u>Bulbochaete</u> sp. De Bary	6
Order Chlorococcales (72)	
Family Chlorococcaceae	
<u>Golenkinia radiata</u> Chodat	5-7
Family Characiaceae	
<u>Characium ambiguum</u> Hermann	1, 7
<u>Characium debaryanum</u> (Reinsch) De Toni	2, 3
<u>Characium pringsheimii</u> A. Braun	2
<u>Characium rostratum</u> Reinhard	5
Family Hydrodictyaceae	
<u>Pediastrum biradiatum</u> Meyen	2, 7
<u>Pediastrum boryanum</u> (Turp.) Meneghini	3
<u>Pediastrum duplex</u> Meyen	2-5, 10
<u>Pediastrum duplex</u> var. <u>gracillimum</u> West & West	5-8
<u>Pediastrum duplex</u> var. <u>reticulatum</u> Lagerheim	4, 5
<u>Pediastrum duplex</u> var. <u>rotundatum</u> Lucks	7
<u>Pediastrum simplex</u> (Meyen) Lemmermann	5
<u>Pediastrum tetras</u> (Ehrenb.) Ralfs	5, 6
<u>Pediastrum tetras</u> var. <u>tetraodon</u> (Corda) Rabenhorst	5
Family Coelastraceae	
<u>Coelastrum cambricum</u> Archer	6
<u>Coelastrum morus</u> West & West	3-8
<u>Coelastrum proboscideum</u> Bohlin	7
<u>Coelastrum sphaericum</u> Nageli	5
Order Rhizosoleniales	
Family Rhizosoleniaceae	
<u>Rhizosolenia longiseta</u> Zacharias	6-8
Order Biddulphiales	
Family Chaetoceraceae	
<u>Attheya zachariasii</u> Brun.	5-8
Order Fragilariales	
Family Tabellariaceae	

- \*Tabellaria fenestrata (Lyng.) Kutzing 1-6, 11  
 \*Tabellaria flocculosa (Roth) Kutzing 1-5, 12  
 Family Fragilariaceae  
 \*Fragilaria brevistriata Grun. 2-4  
 \*Fragilaria capucina var. mesolepta Rabb. Perennial  
 \*Fragilaria crotonensis Kitton 6, 7  
 \*Asterionella formosa Hassal 1-7, 11, 12  
 \*Asterionella formosa var. gracillima (Hantz.) Grunow 1-5  
 \*Synedra delicatissima W. Smith 1-8  
 \*Synedra pulchella (Kutz.) Ralfs 2-8  
 \*Synedra pulchella var. lacerata Hust 2-8  
 \*Synedra rumpens Kutz. 1-8  
 \*Synedra ulna (Nitz.) Ehr. Perennial  
 Order Eunotiales  
 Family Eunotiaceae  
 \*Eunotia curvata (Kutz.) Lagerheim 3, 4  
 \*Eunotia elegans Oestrup 2-4  
 \*Eunotia pectinalis (Kutz.) Rabenhorst 2, 3, 5-7  
 \*Eunotia pectinalis var. ventricosa Grunow 5  
Eunotia sp. Ehrenberg 5-7  
 Order Achnanthales  
 Family Achnanthaceae  
 \*Cocconeis fluviatilis Wallace 3, 4  
 \*Cocconeis placentula Ehrenberg 3, 4  
 \*Cocconeis placentula var. lineata (Ehr.) Cleve 2-8  
 Order Navicuales  
 Family Naviculaceae  
 \*Frustulia rhomboides (Ehr.) deToni 2-4  
 \*Frustulia rhomboides var. crassinervia (Breb.) Ross 2-4  
Amphiprora ornata Bailey 2-4, 7  
 \*Gyrosigma obtusatum (Sulliv.) Boyer 3, 4  
 \*Gyrosigma scalproides (Rhab.) Cleve 1  
Stauroneis acuta W. Smith 2, 3  
 \*Stauroneis anceps Ehrenberg 4  
 \*Stauroneis phoenicenteron (Nitz.) Ehrenberg 3  
 \*Stauroneis phoenicenteron f. gracilis Hustedt 3  
 \*Neidium affine var. amphirhynchus (Ehr.) Cleve 6, 7  
 \*Nitzschia linearis var. tennis W. Smith 2, 3  
 \*Nitzschia obtusa var. brevissima W. Smith 7  
 \*Nitzschia obtusa var. scalpelliformis Grunow 2-4  
 \*Nitzschia punctata Grunow 7  
 \*Nitzschia sigmoidea (Ehr.) W. Smith 3-5, 7  
 \*Nitzschia sublinearis Hustedt 3, 4  
 \*Nitzschia thermalis Kutzing 2-4  
 Order Surirellales  
 Family Surirellaceae  
 \*Cymatopleura solea (Breb.) W. Smith 2, 3  
 \*Surirella angustata Kutzing 3, 4  
 \*Surirella biseriata var. bifrons (W. Smith) Hustedt 6  
 \*Surirella elegans Ehrenberg 3-8  
 \*Surirella ovalis Brebisson 3, 4, 6, 7  
 \*Surirella patella var. neupaueri (Panti) Cleve-Euler 2-4

- \*Surirella robusta var. splendida (Ehr.)  
van Huerck 2, 3
- \*Surirella robusta var. tenera (Greg.)  
van Huerck

Cyanophyta (15)

## Class Myxophyceae

## Order Chroococcales

## Family Chroococcaceae

- Chroococcus sp. Naegeli 3-8, 10
- Anacystis cyanea Drouet & Dailey 5-8, 10, 12

## Order Hormogonales

## Family Oscillatoriaceae

- Spirulina laxa G. M. Smith 6
- Spirulina norstedtii Gomont 5, 6
- Oscillatoria angustissima West & West 7
- Oscillatoria limosa (Roth) Agardh 5-7, 12
- Oscillatoria princeps Vaucher 6
- Oscillatoria sp. Vaucher 5, 6, 11
- Lyngbya birgei G. M. Smith 1, 5-7, 10, 11
- Lyngbya martensiana Meneghini 5

## Family Nostocaceae

- Anabaena affinis Lemmermann 10
- Anabaena circinalis Rabenhorst 5-7
- Anabaena limnetica G. M. Smith 5-8
- Aphanizomenon flos-aquae Ralfs 1, 5-8, 10-12

Euglenophyta (42)

## Class Euglenophyceae

## Order Euglenales

## Family Euglenaceae

- Euglena acus Ehrenberg Perennial
- Euglena ehrenbergii Klebs 6
- Euglena elastica Prescott 5-8
- Euglena minuta Prescott 5-8
- Euglena oxyuris Schmarida 5-7
- Euglena oxyuris var. minor Prescott 1-3, 5-7
- Euglena proxima Dangeard 1, 3-8
- Euglena spirogyra Ehrenberg 7
- Euglena spiroides var. annulata Gojdics 3-8, 10
- Euglena sp. Ehrenberg All but 12
- Phacus brevicaudata (Klebs) Lemmermann 3-5, 10
- Phacus crenulata Prescott 5
- Phacus curvicauda Swirenko 5
- Phacus helicoides Pochman 7
- Phacus lemmermanni (Swir.) Skvortzow 2, 5, 6
- Phacus longicauda (Ehr.) Dujardin 3-7, 10, 11
- Phacus norstedtii Lemmermann 6, 7
- Phacus orbicularis Hubner 5-8
- Phacus pleuronectes (OFM) Dujardin 7
- Phacus suecius Lemmermann 5
- Phacus triqueter Playfair 7, 8
- Lepocinclis acicularis France 5, 7
- Lepocinclis acuta Prescott 5
- Lepocinclis ovum (Ehr.) Lemmermann 6-8
- Lepocinclis texta (Duj.) Lemmermann 5, 7
- Trachelomonas acanthophora Stokes 6, 7
- Trachelomonas armata var. longispina  
(Playf.) DeFlandre 5, 7
- Trachelomonas armata var. steinii  
Lemmermann 7
- Trachelomonas gibberosa Playfair 2, 6, 7
- Trachelomonas hispida (Perty) Stein Perennial
- Trachelomonas hispida var. coronata  
Lemmermann

<u>Trachelomonas hispida</u> var. <u>crenulatorollis</u>	
(Mask.) Lemmermann	4-6
<u>Trachelomonas horrida</u> Palmer	1, 3, 4, 6-8
<u>Trachelomonas kelloggii</u> (Skv.) DeFlandre	5
<u>Trachelomonas playfairii</u> DeFlandre	1
<u>Trachelomonas robusta</u> Swirenko	7
<u>Trachelomonas scabra</u> var. <u>longicollis</u>	
Playfair	
<u>Trachelomonas schauinslandii</u> Lemmermann	3, 5-7
<u>Trachelomonas superba</u> (Swir.) DeFlandre	2, 5-7
<u>Trachelomonas sydneyensis</u> Playfair	7
<u>Trachelomonas volvocina</u> Ehrenberg	All but 1
<u>Trachelomonas zmiewiki</u> Swirenko	2-5

## Pyrrhophyta (12)

## Class Dinophyceae

## Order Gymnodiniales

## Family Gymnodiniaceae

<u>Gymnodinium fuscum</u> (Ehr.) Stein	2, 5
<u>Gymnodinium palustre</u> Schilling	6
<u>Gymnodinium limnetica</u> Lackey	7
* <u>Neidium bisulcatum</u> (Lagerst.) Cleve	7
* <u>Neidium iridis</u> var. <u>ampliatum</u> (Ehr.)	
Cleve	7
* <u>Diploneis finnica</u> (Ehr.) Cleve	2
* <u>Navicula cuspidata</u> Kutzing	3, 5
* <u>Navicula cuspidata</u> var. <u>major</u> Meist.	2-4
* <u>Navicula exigua</u> var. <u>capitata</u> (Grun.)	
Greg.	3
* <u>Navicula mobiliensis</u> var. <u>minor</u> Patrick	2-4
* <u>Navicula radiosa</u> Kutzing	2-4
* <u>Navicula rhynchocephala</u> Kutzing	7
<u>Navicula</u> spp. Bory.	Perennial
* <u>Pinnularia biceps</u> Gregory	3-6
* <u>Pinnularia legumen</u> Ehrenberg	3, 4
* <u>Pinnularia microstauron</u> (Ehr.) Cleve	2-4
* <u>Pinnularia viridis</u> (Nitz.) Hustedt	2-7
* <u>Pinnularia viridis</u> var. <u>commutata</u>	
(Grun.) Cleve	3, 4
* <u>Gomphonema acuminatum</u> Ehrenberg	1-7, 12
* <u>Gomphonema acuminatum</u> var. <u>coronatum</u>	
(Ehr.) W. Smith	2-4
* <u>Gomphonema auger</u> Ehrenberg	7
* <u>Gomphonema constrictum</u> var. <u>capitatum</u>	
(Ehr.) Cleve	2-8
* <u>Gomphonema gracile</u> Ehrenberg	2-4
* <u>Gomphonema parvulum</u> Kutzing	5
* <u>Gomphonema parvulum</u> var. <u>lanceolata</u>	
Kutzing	3-5
* <u>Caloneis lewisii</u> Patrick	2, 6
* <u>Caloneis limosa</u> (Kutz.) Patrick	3, 7

## Family Cymbellaceae

* <u>Cymbella affinis</u> Kutzing	7
* <u>Cymbella cistula</u> Hempr.	
* <u>Cymbella cuspidata</u> var. <u>naviculiformis</u>	
Auersw.	
* <u>Cymbella cymbiformis</u> Ehrenberg	3, 4
* <u>Cymbella ehrenbergii</u> Kutzing	1-3, 5-8
* <u>Cymbella gastroides</u> Kutzing	3, 6
* <u>Cymbella lanceolata</u> (Ehr.) Van Huerck	Perennial
* <u>Cymbella obtusa</u> Gregory	6
* <u>Cymbella tumida</u> (Breb.) van Huerck	6, 7
* <u>Cymbella turgida</u> (Gregory) Cleve	3-5
* <u>Amphora ovalis</u> f. <u>minor</u> Kutzing	3, 5, 7



## Order Epithemiales

## Family Epithemiaceae

- \*Epithemia turgida (Ehr.) Kutzing 1-3, 5-8  
 \*Rhopalodia gibba (Ehr.) Muller 1, 2, 4-8  
 \*Rhopalodia gibba var. ventricosa (Ehr.)  
 Grunow 6, 7

## Order Nitzschiales

## Family Nitzschiaceae

- \*Nitzschia fasciculata Grunow 3, 7

## Order Peridinales

## Family Glenodiniaceae

- Glenodinium sp. (Ehr.) Stein 6-8  
Glenodinium quadridens (Stein) Schiller 7, 8

## Family Peridiniaceae

- Peridinium aciculiferum Lemmermann 6, 7  
Peridinium cinctum (Muell.) Ehrenberg 5-8  
Peridinium cinctum var. tuberosum  
 (Meunier) Lindemann 5  
Peridinium limbatum (Stokes) Lemmermann 6  
Peridinium pusillum (Penard) Lemmermann 4-6  
Peridinium wisconsinense Eddy 7

## Family Ceratiaceae

- Ceratium hirundinella (Muell.) Dujardin 6-8, 1

Cryptophyta (2)

## Class Cryptophyceae

## Order Cryptomonadales

## Family Cryptomonaceae

- Cryptomonas erosa Ehrenberg Perennial  
Cryptomonas spp. Ehrenberg Perennial

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## **Federalism and its Impact on NSF Grants and the Training of Teachers<sup>1</sup>**

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### **ABSTRACT**

The greatest challenge for science and mathematics education in the '80's is the establishment of realistic goals for developing a scientifically literate society, and the preparation and enhancement of the talent pool for the research and development, and the technological support essential for human welfare in a world increasingly dependent on science and technology. Recent studies and surveys indicate declining knowledge and interest in science and mathematics among pre-college students; yet, the federal government and, in many cases, state governments have abandoned the aggressive efforts of the post-Sputnik era to improve the quality of science and mathematics education. Teacher preparation suffers in both quality and quantity. Science and mathematics education centers are being devastated by retrenchment policies. Instructional materials and supplies are inadequate. Teachers are leaving the classroom for more financially rewarding careers. In-service-continuing education opportunities to upgrade teacher knowledge and keep teachers alive professionally have been drastically reduced. Our challenge is to modify the policies and practices responsible for the present status, so that science, mathematics and technological education for the '80's will be strengthened.

This paper is dedicated to the thousands of science teachers who daily perform the task of teaching the youth of this country in high quality programs in science education. Despite the continuing criticisms in the news media and public meetings, and inadequate support, they continue to produce from among our top students the best scientific talent in the world.

### **INTRODUCTION AND OVERVIEW**

The annals of science education literature are replete with yearbooks and commission studies analyzing and delineating the problems of science education for the past hundred

<sup>1</sup>A presentation given to the 1983 NAAS/AAAS Symposium: The Crises in Science and Mathematics Education.

years. The collection in my office currently occupies 12 linear feet of shelf space. All of you present today are familiar with most of the yearbook and commission studies published during the past two decades; therefore, it is the choice of the writer not to bore you with the redundancy of the commission findings and recommendations. The writer would, however, like to emphasize the tremendous change that has come about in American education since the publication of the Committee of Ten Report in 1893, which recommended a highly content structured program of preparation in science for the 8 to 11 percent of the 14-17 year old school population who attended secondary schools at that time. These recommendations were made despite the fact that only 2 percent of the eligible school age population actually graduated from high school. These data need to be compared and contrasted with the recommendations concerning the curriculum development and implementation of the 60's and 70's when 90 percent of the school age population were in school and 75 percent of the eligible population graduated from high school. Obviously, the demands on the schools and upon the teachers of specialized areas, such as science and mathematics, are much more diverse in the 1980's than the 1890's. Yet one could easily deduce, from recent recommendations for a return to the rigors of the past, that many feel the academic program recommended by the Committee of Ten would suit the youth of today.

### CHANGING ORGANIZATIONAL PATTERNS OF SCHOOLS AND CONFLICTING DEMANDS OF THE PUBLIC

It is probably safe to assert that no other educational system in the world has attempted to do as much for so many as we have in the 50 states of this great nation. By attempting to educate all of the children of all of the people we have increasingly placed our teachers in situations requiring them to teach not only the content of the academic discipline in which they should be prepared, but to deal with an ever increasing number of social issues from a complex and ever changing society. The awareness of social injustices of the past and the desire to solve the problems and injustices created by discriminatory actions have also increased demands on teacher's time and commitment. In the midst of this school climate, and increasing awareness of the need for protection of individual student rights and freedom, classroom standards for control and self-discipline became very much confused. Standards for student performance deteriorated. The public cry for accountability sounded louder and louder until "Back to Basics" became the marching theme from coast to coast.

#### Problems—Challenges—Crises?

Several important areas to be discussed in the remaining section of this paper deal with the problems and challenges confronting the science education community, which if not attended to will certainly become crises.

#### *Goals for Science Education*

We need to address ourselves, in the science education community, to agree upon two realistic and attainable goals. (1) The teaching of science for development of the scientific talent in the academic disciplines for future careers in science, mathematics, engineering, and technology, and (2) a commitment to the development of scientific literacy in the total population, for fuller understanding and enjoyment of the world of nature and technology, and wiser decision making regarding the problems of daily living in the

technological society of today and tomorrow.

The curriculum development efforts post-Sputnik under the support of the National Science Foundation funding, and quality control by specialists and teachers, had the most significant impact of any other individual effort in the history of American education. Despite much data accumulated in the national surveys showing that the curriculum projects fell short of their stated goals, it certainly cannot be argued that the curriculum projects failed to infuse the schools K-12 with up-to-date science content. In retrospect, many of the courses and programs may have been overly structured in terms of the academic discipline at the expense of eliminating most or all of the technology, which for many provided the interest and motivation for the study of the applications of science. The major failures of the curriculum project movement of the 60's and 70's can be categorized as the implementation activities, or lack thereof. The curriculum development and implementation phases were not buttressed by teacher preparation programs, conducted by knowledgeable, enthusiastic, dedicated individuals. This is not to say that the support for summer institutes, academic year institutes, and in-service teacher preparation programs was inadequate, but simply to assert that because of the lack of coordination, the left hand did not know what the right hand was doing, and the teacher preparation activities, in many cases, provided negative support for the curriculum development products and implementation efforts.

### *Support Mechanisms*

A continuing, perplexing problem of American education is the lack of clearly defined roles for the federal, state, and local governments in the financial support of education. The disparity among the financial bases of local communities at the state level and among states at the national level means that a local community within a state may expend a tenfold effort when compared to another local community within the state and still provide inadequate financial support for needed educational services. The same is true when the poorest state is compared to the wealthiest state in terms of tax base and effort. Such inequities must be addressed individually by the states and also by the federal government.

During the post-World War II era, communities provided the financial support for the construction of school facilities unequalled in our history. However, with increasing inflation, the rising cost of living and higher taxes the public revolt of the late 70's left public education at the mercies of supercritical and unsupportive electorates. Teachers were expected to perform miracles in instructional programs with science, where the total equipment and instructional supplies budget per pupil annually was less than the cost of a ticket, with refreshments, for a NFL football game. Teachers' salaries were inadequate and the annual increases were zero to a fractional part of the inflation rate.

### *The Abdication of Responsibility for Teacher Preparation*

In the mid-50's and the post-Sputnik era science education in America, and internationally, witnessed a great resurgence of cooperative efforts on the part of scientists, engineers, technicians, and educators under the auspices of National Science Foundation support. College and university professors in all of the major disciplines of science devoted themselves to special programs for teacher preparation, the undergraduate and graduate continuing education. However, with much of the conflict surrounding concerns for social issues in the 70's and the decline in federal financial support for science and mathematics education activities most of the academic scholars retreated to their research laboratories, where they could be safe from public ridicule, and more secure in the financial support of continuing research grants.

Much of the preceding discussion is too negative, and too candid an indictment of the scientific and education communities of this country. However, if we are to solve the problems of the future we must be willing to share the responsibilities for our individual actions and the blame for our failures as readily as we are willing to accept the accolades for our achievements when we succeed. Fortunately there are many positive indicators which should serve as guides in the search for solutions to our current problems. The public seems receptive to massive changes in educational programs. The states are redefining standards for instructional programs, and mathematics and science requirements are being increased nationwide. Departments of teacher certification are establishing higher standards for the certification of science teachers. Colleges and universities are making concerted efforts to enroll more teachers in undergraduate programs leading to certification in the sciences and mathematics.

The challenge remains, from the White House and the Halls of Congress to the local school board and the principal's office, for executive, legislative, and administrative policies and financial support for excellence in instructional programs. The same is true, from the President's Science Advisor and the National Science Board to the college professor, to the local science supervisor, regarding responsibilities for establishment of professional policies and support which have academic merit and credibility. The preparation of science teachers for the future is too important and too massive an undertaking to be left to the discretion of a small cadre of science education specialists in far too limited number of colleges and universities. It must be the responsibility of the whole scientific community.

#### Past and Future Roles of NSF Grants and the Training of Teachers

Little has been stated explicitly, but much has been implied in the preceding sections of this paper regarding the impact of the new Federalism on NSF's participation in the training of science and mathematics teachers. However, from reading the myriad of reports and studies from the inception of the National Science Foundation to the present it is not clear that all of the reduction in NSF participation in science and mathematics education activities at the pre-college level have been due to the new Federalism. From a very meager beginning in 1952, with an expenditure of \$7,000 plus for science education research and analysis the support and involvement of NSF grew to a maximum \$124 million for each of the years 1966-68, and then diminished to practically zero in 1983. A graph of the expenditures during that period of time represents an almost perfect Bell curve. The support initially for teacher education in Summer Institutes, then Academic Year Institutes, followed by Course Content Development Projects in the disciplines and implementation activities including specialized teacher training involved estimates of 50-60 percent of the mathematics and science teachers grades 7-12. During the peak period of financial support and teacher participation it is estimated that as many as 30 percent of the teachers in mathematics and science were provided the best of training, and/or continuing education in combinations of Summer Institutes, In-service Institutes, and Cooperative College School Science Programs. The role of NSF was clearly that of providing, as authorized by the National Science Foundation Act of 1950, "financial support for the scientific and educational activities and the appraisal of the impact of such activities upon the general welfare." The secondary role of NSF, unrecognized by many in the scientific community, was the establishment and maintenance of standards through the peer-review system for programs in teacher training at the graduate, and continuing education levels. The established standards directly

effected positive changes in undergraduate teacher education programs. With the precipitous decline in funding of the Science Education Directorate within the National Science Foundation, beginning in 1969, the role that NSF could play, and has played in helping to establish and maintain standards of excellence in science and mathematics education at the pre-college level diminished significantly. It is the considered judgment of this writer that the future role of NSF must be to help reestablish those standards by the provision of the scholarly expertise, and serving as the major conduit of financial support for redefined and reestablished programs of excellence in science, mathematics, engineering, and technological education. To reestablish and redefine its role NSF must have the support from the new generation of young scientists, mathematicians, engineers, and teachers who constitute the membership of the scientific societies and associations, such as the National Association of Academies of Science and the American Association for the Advancement of Science. With the concerted and cooperative efforts of all such interested persons the declines of the past ten years can be reversed and sound programs of teacher preparation for the future can be reestablished.

## Requested Amendment to ByLaws

Proposed Bylaw changes must be distributed to the membership or published in the Virginia Journal of Science at least 30 days prior to action by Council. Adoption requires an affirmative vote of a majority of the total membership of Council. Action on the proposed changes presented here is planned for the March Council meeting.

The Nominations and Elections Committee and Council have recommended that the following amendment to the Bylaws be processed;

Section 10. Nominations and Elections Committee shall:

- (1) Mail to the membership on or about January 1 each year a request for nominations of persons to fill the offices of President-elect, Secretary and Treasurer.
- \* (2) Nominate a slate of two persons for each of the aforementioned offices and present to March Council Meeting.
- (3) Mail slate of nominees to members advising that names may be added to the slate by 25 members petitioning the committee on behalf of each name to be added.
- (4) Prepare ballots with or without additional nominees as the case may be and mail to membership with registration and other information relative to annual meeting indicating deadline and address for return of ballot to committee.
- (5) Count ballots and announce results at the Academy Conference. Should a tie vote result for any office, the Academy Conference shall vote on the nominees. In all cases, the nominee receiving the largest number of favorable votes shall be elected; provided, however, that only members in good standing may cast ballots.

\*Amend paragraph (2) by striking "present to March Council Meeting" and substituting "report to Council for informational purposes."



## Jeffress Research Grant Awards

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Mr. Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical or other natural sciences through grants to non-profit education and research institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced have been awarded in the period from February 1982 through May 1983.

The Jeffress Memorial Trust is administered by First & Merchants National Bank of Richmond. Additional information about the program of the Trust may be obtained by writing the Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, Trust Department, First & Merchants National Bank, P.O. Box 26903, Richmond, Virginia 23261.

Bruce M. Anderson, Virginia Tech. Mechanistic studies of 20-A-hydroxysteroid dehydrogenase. \$49,374 (three years)

Bulent Atalay, Mary Washington College. Perturbation Theory for Projected States. \$5,200 (two years)

Robert K. Boggess, Radford College. The Synthesis, Electrochemical, and Luminescence Investigation of Ruthenium (II) Polypyridine Complexes and Other Studies of Pyridine Ligands. \$26,800 (two years)

Kang Cheng, University of Virginia. Mechanism of action of insulin: study of existence of a cell membrane protease signalling factor. \$60,000 (two years)

Michael J. Cloutier, Virginia Tech. Regulation of cellular differentiation by differential gene expression. \$13,580 (two years)

Donald G. Cochran, Virginia Tech. Uric acid excretion in the woods cockroach, Parcoblatta fulvescens. \$14,965 (two years)

Mark S. Conradi, The College of William and Mary. NMR and Dielectric Studies of Quadrupolar Glasses. \$42,690 (three years)

Cecil S. Cummins, Virginia Tech. A proposal to investigate the structure of the cell wall polysaccharides in propioni-bacteria. \$75,486 (three years)

Gary C. Defotis, The College of William and Mary. Experimental Studies of Critical Behavior and Phase Diagrams in Dilute and Mixed Magnetic Systems. \$38,683 (three years)

J. B. Delos and S.K. Knudson, The College of William and Mary. Classical and Quantum Mechanics of Atoms in Strong Magnetic Fields. \$38,788 (two years)

Mark Failla, Virginia Tech. Accumulation of copper in the kidney of the streptozotocin diabetic rat: location and influence of the metal on tissue function. \$32,633 (two years)

Robert M. Grainger, University of Virginia. Control of developmental pathways in embryonic tissues. \$98,874 (three years)

Stephen Goldberg and J. Ross McClung, Virginia Commonwealth University. Structure-function relationships in extraocular motor units. \$104,290 (three years)

Brian E. Hanson, Virginia Tech. Investigation of Catalytic Materials by Dynamic High Resolution  $^{31}\text{P}$  NMR Spectroscopy. \$51,345 (three years)

W. John Hayden, University of Richmond. Comparative stem ontogeny and phyllome anatomy in Chamaesyce and Euphorbia subgenus Agaloma. \$10,893 (two years)

Alan G. Heath, Virginia Tech. Development of a way to measure energy status and growth of a population of fish under stress. \$5,645 (one year)

P. Jena, Virginia Commonwealth University. Electronic Structure of Defect Complexes. \$40,500 (three years)

Robert A. Jordan, Hampton Institute. Microecological factors associated with the occurrence of Acanthamoeba species (sarcominid protozoans). \$65,000 (one year)

Bruce L. King, Randolph-Macon College. Flavonoid systematics of Lychnophora (vernonieae: compositae). \$24,800 (two years)

Kenneth R. Lawless, University of Virginia. High Resolution and Analytical Electron Microscopy Studies of Selected Catalysts. \$87,695 (three years)

Joseph P. Liberti, Virginia Commonwealth University. Translational control of collagen biosynthesis by somatomedin. \$56,340 (two years)

Burton J. Litman, University of Virginia. Research projects for an automatic recording spectropolarimeter. \$46,167 (one year)

Robert E. Ludt, Virginia Military Institute. Heteroatom Directed Lithiation of Aromatic Compounds. \$20,175 (three years)

Francis L. Macrina, Virginia Commonwealth University. Genetics of antibiotic resistance in bacteriodes. \$64,144 (three years)

Orson K. Miller, Virginia Tech. A study of the higher fungi of Virginia. \$12,500 (three years)

Larry Nichter, University of Virginia. Improving longterm patency in microvascular autogenous and synthetic grafts. \$8,600 (one year).

Walter G. Niehaus, Virginia Tech. Mechanisms of regulation of fungal secondary metabolism. \$67,316 (three years)

Blaine E. Norum, University of Virginia. Electro-nuclear Studies Using the NIKHEF-K Medium Energy Electron Accelerator. \$83,300 (three years)

John L. Patterson, Jr., Virginia Commonwealth University. Spectral analysis of respiratory sound. \$79,049 (three years)

S. J. Poon, University of Virginia. Experimental Investigations of Magnetic Interactions and Non-kondo Resistivity Anomalies in Metallic Glasses. \$34,340 (two years)

Jonathan Ravdin, University of Virginia. Entamoeba histolytica: mechanisms and prevention of amebic adherence and cytotoxicity. \$86,215 (three years)

Lionel I. Rebhun, University of Virginia. Investigations of multiple forms of tubulin in dividing and non-dividing cells. \$103,400 (three years)

William S. Shear, Hampden-Sydney College. Study of fossils of terrestrial arthropods from the Devonian of Gilboa, New York. \$31,000 (one year)

Peter J. Sims, University of Virginia. A biophysical study of the interaction of complement proteins C5B-9 with lipid containing membranes. \$82,161 (three years)

Barry E. Stein, Virginia Commonwealth University. Superior colliculus and pain. \$146,842 (three years)

James A. Stevenson, Virginia Commonwealth University. Optic axon growth from peripheral nerve grafts. \$23,470 (two years)

Ronald P. Taylor, University of Virginia. Characterization of pathogenic DNA-antibody complexes. \$6,500 (one year)

James Turner, Virginia Commonwealth University. Rapid Mixing Resonance Raman Spectroscopy of Peroxidase and Catalase Intermediates. \$59,360 (three years)

David W. Thompson, The College of William and Mary. Organic Synthesis through Early Transition Metal Organometallic Chemistry. \$30,150 (three years)

Stephen T. Thornton, University of Virginia. Mass Measurements of Exotic Nuclei. \$37,000 (three years)

Wayne H. Tinnell, Longwood College. Genetic transfer in oral anaerobes. \$5,400 (one year)

Richard W. Topham, University of Richmond. The physiological significance of a serum ferroxidase inhibitor. \$62,916 (two years)

David W. Towle, University of Richmond. An investigation of membrane function in ion-transporting cells of blue crab gill. \$46,975 (three years)

W. Peter Trower, Virginia Tech. Four Exploratory Research Projects in Physical Science. \$36,000 (three years)

Bruce J. Turner, Virginia Tech. Mitochondrial DNA as new tool for probing the evolutionary biology and genetic structure of fish populations. \$12,230 (one year)

Bart Van't Riet, Virginia Commonwealth University. Antitumor Agents Containing Polyhydroxyphenyl Rings. \$38,400 (three years)

Bruce Wallace, Virginia Tech. The genetic assimilation of a heat-shock-induced phenotype in Drosophila melanogaster. \$2,360 (two years)

R. C. Whisonant, Radford College. Fabric and origin of intraclasts in Some Cambro-Ordovician carbonates, Southwestern Virginia. \$21,470 (two years)

Robert H. White, Virginia Tech. Biosynthesis of coenzyme M in methanogenic bacteria. \$12,970 (two years)

John L. Wiktorowicz, Virginia Tech. Molecular biology of globin gene expression in human cultured cells. \$25,486 (one year)

A. A. Yousten, Virginia Tech. An investigation of bacillus laterosporus: A bacterium causing disease in mosquito larvae. \$12,525 (two years)

# Mountain Lake Biological Station Announcement

## A N N O U N C I N G

### MOUNTAIN LAKE BIOLOGICAL STATION

#### SUMMER COURSES 1984

#### First Term (June 11 - July 14)

##### Herpetology

Ronn Altig, Mississippi State  
University

##### Ornithology

Val Nolan, Jr., Indiana University  
Ellen Ketterson, Indiana University

##### Plant Ecology

Elizabeth Lacey, University of North  
Carolina-Greensboro

##### Quantitative Methods in Field Biology

Joseph Travis, Florida State  
University

##### Workshop in Allozyme Techniques

Charles R. Werth, College of William  
and Mary

#### Second Term (July 16 - August 18)

##### Biology of Insects

George W. Byers, University of  
Kansas

##### Community Ecology

Norman Christensen, Duke University  
Henry Wilbur, Duke University

##### Freshwater Ecology

Daniel J. Hornbach, University of  
Virginia

##### Natural History of the Southern Appalachians

Robert C. Simpson, Lord Fairfax  
Community College

##### Nature Photography

Robert C. Simpson, Lord Fairfax  
Community College

##### Workshop in Allozyme Techniques

Charles R. Werth, College of  
William and Mary


Scholarships Available: Service Awards for students covering room and board costs.  
Post-Doctoral Research Awards (10 weeks)

For further information and application write to:

Dr. Jerry O. Wolff, Director  
Mountain Lake Biological Station  
Gilmer Hall  
University of Virginia  
Charlottesville, VA 22901

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